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ABSTRACT

This hearing report covers three bills: (1) H.R. 3750, which would authorize grants to local educational agencies to purchase computer equipment; (2) H.R. 1134, which would provide funds to establish and operate model centers for computers in education; and (3) H.R. 4628, which would establish a government corporation to promote the development and distribution of high quality educational software. Following the text of the three bills, statements and testimony are included from the following individuals: Judy Anderson, East Consolidated School District, St. Paul, Minnesota, accompanied by Robert Pope, student, East Consolidated Elementary; Dorothy K. Deringer, Atari Learning Systems; Representative Thomas J. Downey (New York); Representative Albert Gore, Jr. (Tennessee), accompanied by Chancellor Joe B. Wyatt, Vanderbilt University; Senator Frank R. Lautenberg (New Jersey); Marc Tucker, Project on Information Technology and Education; Representative Timothy E. Wirth (Colorado). Prepared statments, letters, and supplemental materials are also included from Judy Anderson; the Association of American Publishers; Lewis M. Branscomb, International Business Machines Corp.; Dorothy K. Deringer; Thomas J. Downey; Albert Gore, Jr.; Edward P. Keller, National Association of Elementary School Principals; Ray Kline, General Services Administration; Frank R. Lautenberg; Representative Carl D. Perkins (Kentucky); Robert Pope; Marc S. Tucker; Representative Jim Weaver (Oregon); Timothy E. Wirth; and Joe B. Wyatt. (LMM)

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HEARING ON COMPUTER EDUCATION

HEARING

BEFORE THE

SUBCOMMITTEE ON ELEMENTARY, SECONDARY,
AND VOCATIONAL EDUCATION

OF THE

COMMITTEE ON EDUCATION AND LABOR
HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

ON

H.R. 3750

TO PROVIDE ASSISTANCE TO LOCAL EDUCATIONAL AGENCIES AND INSTITUTIONS OF HIGHER EDUCATION TO PROMOTE COMPUTER LITERACY AMONG ELEMENTARY AND SECONDARY SCHOOL STUDENTS AND THEIR TEACHERS, AND FOR OTHER PURPOSES

H.R. 1134

TO AMEND TITLE III OF THE ELEMENTARY AND SECONDARY EDUCATION ACT OF 1965 TO PROVIDE FOR ONE OR MORE NATIONAL CENTERS FOR PERSONAL COMPUTERS IN EDUCATION

H.R. 4628

TO ESTABLISH A NATIONAL EDUCATIONAL SOFTWARE CORPORATION TO PROMOTE THE DEVELOPMENT AND DISTRIBUTION OF HIGH-QUALITY, INTERACTIVE, AND EDUCATIONALLY USEFUL COMPUTER SOFTWARE, AND FOR OTHER PURPOSES

HEARING HELD IN WASHINGTON, DC, ON MAY 1, 1984

Printed for the use of the Committee on Education and Labor

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HEARING ON COMPUTER EDUCATION

TUESDAY, MAY 1, 1984

House of Representatives,
Committee on Education and Labor,
Subcommittee on Elementary, Secondary,
and Vocational Education,
Washington, DC.

The subcommittee met, pursuant to call, at 8:50 a.m., in room 2175, Rayburn House Office Building, Hon. Carl D. Perkins (chairman of the subcommittee) presiding.

Members present: Representatives Perkins, Miller, Packard, Gunderson, and Bartlett.

Staff present: John F. Jennings, majority counsel; Nancy Kober, legislative specialist; and Richard di Eugenio, Republican senior legislative associate.

Chairman **Perkins**. The subcommittee will come to order. This morning the Subcommittee on Elementary, Secondary, and Vocational Education is conducting a hearing on the issue of computer education and computer literacy for our Nation's elementary and secondary school children and teachers.

Three bills are currently pending before the subcommittee dealing with different aspects of this general topic. H.R. 3750, introduced by our colleague Tim Wirth, would authorize $300 million for each of the fiscal years 1984 through 1993 for grants to local educational agencies to purchase computer equipment.

H.R. 1134, upon which the subcommittee conducted a hearing on April 21, 1983, was sponsored by Congressman Downey. This bill would provide funds to establish and operate model centers for personal computers in education. These centers would develop and evaluate software, train teachers, and offer other types of technical assistance to educational agencies. The bill authorizes $4 million which can be spread over 3 fiscal years.

Congressman Gore's bill, H.R. 4628, would establish a government corporation to promote the development and distribution of high quality educational software. For this purpose, $15 million is authorized for each of the fiscal years 1985, 1986, and 1987.

[Texts of H.R. 3750, H.R. 1134, and H.R. 4628 follow:]

I

98th CONGRESS
1st Session

H. R. 3750

To provide assistance to local educational agencies and institutions of higher education to promote computer literacy among elementary and secondary school students and their teachers, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

August 3, 1983

Mr. Wirth (for himself, Mr. Perkins, Mr. Miller of California, Mr. Downey of New York, Mr. Gephardt, Mr. Kogovsek, Mr. Walgren, Mr. Coelho, Mr. Dellums Mrs. Boggs, Mr. Florio, Mr. Moakley, Mr. Simon, Mr. Mineta, Mr. Frost, Mr. Foley, Mr. Mitchell, Mr. Williams of Montana, Mrs. Hall of Indiana, Mr. Torricelli, Mr. Matsui, Mr. Leland, Mr. Murtha, Mr. Edwards of California, Mr. Frank, Mr. Berman, Mr. Flippo, Mr. Patterson, Mr. Stark, Mr. Neal, Mrs. Schroeder, Mr. Scheuer, Mr. Shannon, Mr. Hoyer, Mr. McHugh, Mr. Markey, Mr. Kildee, Mr. Seiberling, Mr. Levin of Michigan, Mr. Pepper, and Mr. Ratchford) introduced the following bill; which was referred jointly to the Committees on Education and Labor and Science and Technology

---

A BILL

To provide assistance to local educational agencies and institutions of higher education to promote computer literacy among elementary and secondary school students and their teachers, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Computer Literacy Act of 1983".

TITLE I—ACQUISITION OF COMPUTER HARDWARE

PURPOSES

SEC. 101. It is the purpose of this title to authorize assistance to local educational agencies for the acquisition of computer hardware for use in school classrooms in order to promote student competence in the operation and use of new technologies, and thereby to improve students' academic performance in both technical and other fields.

DEFINITIONS

SEC. 102. For purposes of this title—

(1) the term "Secretary" means the Secretary of Education;

(2) the term "local educational agency" has the meaning provided in section 198(a)(10) of the Elementary and Secondary Education Act of 1965;

(3) the term "State educational agency" has the meaning provided in section 198(a)(17) of such Act;

(4) the term "average daily attendance" has the meaning provided in section 198(a)(1) of such Act;

(5) the term "computer hardware" means—

(A) a data processor which—

(i) can be programed in at least three standard computer languages;

(ii) has a random access memory capacity of at least sixteen thousand bytes; and

(iii) is or can be connected with a screen for visual display;

(B) in connection with such a data processor (i) a display screen, and (ii) one or more disk or tape drives; and

(C) any equipment necessary for the installation of equipment described in subparagraphs (A) and (B); and

(6) the term "State" means each of the fifty States, the District of Columbia, Puerto Rico, Guam, American Samoa, the Virgin Islands, the Trust Territory of the Pacific Islands, and the Northern Mariana Islands.

ALLOCATION OF FUNDS

SEC. 103. (a)(1) From 5 per centum of the amount appropriated pursuant to section 107 for any fiscal year the Secretary shall allocate to each State educational agency an amount for monitoring and enforcement which bears the same ratio to such 5 per centum as the amount allocated to the local educational agencies in that State under paragraph

(2) for such fiscal year bears to the sum of the amount allocated to local educational agencies in all the States under such paragraph for such fiscal year.

(2) From the remainder of the amount appropriated pursuant to section 107 for any fiscal year the Secretary shall allocate to each eligible local educational agency an amount which bears the same ratio to such remainder as the number of children in average daily attendance in the schools of such local educational agency bears to the sum of such children in the schools of all local educational agencies.

(b) Notwithstanding subsection (a)(2), the allocation of any local educational agency shall be reduced to the extent that assistance under this title has been or would be in excess of the amount necessary for such agency to acquire one unit of computer hardware for each thirty children in average daily attendance in the schools of such agency.

LOCAL APPLICATION FOR FUNDS

SEC. 104. (a)(1) A local educational agency shall be eligible for an allocation under section 103 if it has on file with the State educational agency a current application, approved by the State educational agency, describing the computer hardware procurement program to be conducted with assistance provided under this title. Such application shall contain—

(A) assurances that the local educational agency will allocate funds among the school within its district so that—

(i) funds are provided first to those schools with the least computer hardware per student;

(ii) funds are not provided to any school after such school has the equivalent of one unit of computer hardware for each thirty children in average daily attendance at such school;

(B) an identification of the computer hardware which are already available in the schools of such agency, a specification of the computer hardware to be acquired with funds provided under this title during the next funding period, and assurances that the acquisition cost of such hardware will be reasonable and in accordance with such guidelines as may be prescribed by the Secretary by regulation; and

(C) describe the programs and procedures which the local educational agency has developed to ensure the participation of parents in the establishment of its computer hardware acquisition program and in the development and implementation of a curriculum for the use of such hardware.

(2) Such an application may be amended at any time to describe changes in or additions to the activities originally set forth in the application.

(b) An application or amendment thereto shall be approved by the State educational agency unless such agency determines that the application does not provide for the use of such funds in a manner which meets the requirements of this title or is inconsistent with such requirements as the Secretary may prescribe by regulation. No such determination shall be made except after notice and opportunity for a hearing is given to the applicant.

STATE RESPONSIBILITIES

SEC. 105. (a) Each State which desires to have its local educational agencies qualify for assistance under this title shall have on file with the Secretary an application submitted by its State educational agency. Each such application shall contain (1) satisfactory assurances that the State educational agency will comply with the requirements of this section; and (2) such information as the Secretary considers necessary to determine whether such assurances will be carried out.

(b) A State educational agency shall not finally disapprove, in whole or in part, the application of any local educational agency under section 104 without first affording such agency reasonable notice and opportunity for a hearing.

(c) Each State educational agency shall—

(1) adopt standards, consistent with minimum standards prescribed by the Secretary, for monitoring, with the funds provided under section 103(a)(1), the effectiveness of computer hardware procurement programs assisted under this title;

(2) adopt written procedures for receiving complaints regarding such programs;

(3) establish procedures for notifying the Secretary of any failure by a local educational agency to comply with this title, regulations prescribed thereunder, or any provision in its application; and

(4) make provision for audits of expenditures of funds received under this title to determine, at a minimum, the fiscal integrity of grant and subgrant financial transactions and reports, and compliance with applicable statutes, regulations, and terms and conditions of the grant or subgrant.

(d) Each State educational agency shall submit, at such times and in such detail as the Secretary may require, such reports as may be necessary to enable the Secretary to carry out this title, and shall keep such records and afford such access thereto, as the Secretary may require.

PARTICIPATION OF CHILDREN FROM PRIVATE SCHOOLS

SEC. 106. (a) To the extent consistent with the number of children in the school district of the local educational agency who are enrolled in private elementary and secondary schools, such agency shall, after consultation with appropriate private school representatives, make provision for including special educational services and arrangements (such as dual enrollment, educational radio and television, and mobile educational services and equipment) in which such children can participate and which meet the requirements of this title Expenditures for educational services and arrangements pursuant to this subsection for children in private schools shall be equal (taking into account the number of children to be served and the needs of such children) to expenditures for children enrolled in the public schools of such agency.

(b) If by reason of any provision of law a local educational agency is prohibited from providing for the participation of children from private schools as required by subsection (a), or if the Secretary determines that a local educational agency has substantially failed or is unwilling to provide for such participation on an equitable basis, the Secretary shall waive such requirements and shall arrange for the provision of services to such children, which shall be subject to the requirements of this section. Such waivers shall be subject to consultation, withholding, notice, and judicial review in accordance with section 557(b) (3) and (4) of the Education Consolidation and Improvement Act of 1981.

AUTHORIZATION OF APPROPRIATIONS

SEC. 107. There are authorized to be appropriated to carry out this title $300,000,000 for each of the fiscal years 1984 through 1993.

TITLE II—TEACHER TRAINING INSTITUTES

NATIONAL SCIENCE FOUNDATION PROGRAM

SEC. 201. (a) From the amount appropriated pursuant to section 203 for any fiscal year, the National Science Foundation shall arrange, through grants and contracts with nonprofit professional scientific or engineering organizations, science museums, regional science education centers, State educational agencies, and institutions of higher education (including community colleges), for the development and operation by such entities of short-term or regular session institutes for advanced study to improve the qualifications of individuals who are engaged in or preparing to engage in the teaching, or supervising or training of teachers, of the operation and use of new technologies.

(b) In making grants and contracts under subsection (a), the National Science Foundation shall give special consideration to institutes training teachers, or supervisors or trainers of teachers, serving or preparing to serve in elementary and secondary schools enrolling substantial numbers of culturally, economically, socially, and educationally handicapped youth or in programs for children of limited English language proficiency.

STIPENDS

SEC. 202. Each individual who attends an institute operated under the provisions of this title shall be eligible (after application therefor) to receive a stipend at the rate of $275 per week for the period of attendance at such institute.

AUTHORIZATION OF APPROPRIATIONS

SEC. 203. There are authorized to be appropriated to carry out this title $20,000,000 for each of the fiscal years 1984 through 1993.

TITLE III—INFORMATION DISSEMINATION AND EVALUATION

NATIONAL INSTITUTE OF EDUCATION

SEC. 301. (a) For the purpose of providing advice and technical assistance to State and local educational agencies on the expenditure of funds under title I of this Act and on the acquisition of suitable computer software, the National Institute of Education and the National Science Foundation, in accordance with an interagency agreement between such Institute and such Foundation, shall—

(1) evaluate available computer hardware and software, in terms of its usefulness in the classroom;

(2) disseminate the results of such evaluation; and

(3) develop model computer educational software, and make such model software (and its design premises) available to computer software producers and distributors, teachers, and school administrators.

(b) The Institute and the Foundation shall carry out the functions described in paragraphs (1), (2), and (3) of subsection (a) under grants or contracts made with funds appropriated under subsection (c).

(c) There are authorized to be appropriated to carry out this section such sums as may be necessary for each of the fiscal years 1984 through 1993.

PRIVATE EVALUATION AND DISSEMINATION CENTERS

SEC. 302. (a) The National Science Foundation shall, through grants to or contracts with nonprofit professional scientific or engineering organizations, science museums, regional science education centers, public television, State educational agencies, and institutions of higher education (including community colleges), conduct, assist, and foster research and experimentation on, and dissemination of, models of instruction in the operation and use of computers. In selecting such entities for such grants or contracts, the Foundation shall give priority to those proposals—

(1) prepared with the active and broad community involvement of such groups as parents, teachers, school boards and administrators, and local business; or

(2) which propose the establishment of model training programs for adults.

(b) Funds available under a grant or contract pursuant to this section may be used for the acquisition of computer hardware and software.

(c) The Director of the National Science Foundation shall report to the Congress annually on the results of research and experimentation performed with funds made available under this section. The Director, in conjunction with the National Institute of Education, shall take such steps as may be necessary to disseminate information concerning such results to local educational agencies.

(d) There are authorized to be appropriated to carry out this section such sums as may be necessary for each of the fiscal years 1984 through 1993.

I

98TH CONGRESS
1ST SESSION

H. R. 1134

To amend title III of the Elementary and Secondary Education Act of 1965 to provide for one or more National Centers for Personal Computers in Education.

IN THE HOUSE OF REPRESENTATIVES

FEBRUARY 1, 1983

Mr. DOWNEY of New York introduced the following bill; which was referred to the Committee on Education and Labor

---

A BILL

To amend title III of the Elementary and Secondary Education Act of 1965 to provide for one or more National Centers for Personal Computers in Education.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That title III of the Elementary and Secondary Education Act of 1965 (20 U.S.C. 2941 et seq.) is amended by adding at the end thereof the following new part:

"PART N—COMPUTERS IN EDUCATION

"PROGRAM AUTHORIZED

"SEC. 393. (a) Subject to the availability of funds to carry out this part, the Secretary shall award grants for the establishment and operation of National Centers for Personal Computers in Education (hereinafter in this part referred to as a 'Center') to instruct students in the use of personal computers and to develop programs designed to utilize personal computers and microcomputers as educational tools at all educational levels. No grant may be awarded under this part except to a person or entity which has submitted an application under section 394 which has been approved by the Secretary. Any grant awarded under this part shall, subject to the availability of funds under this part, be sufficient to permit the recipient to operate a Center for a three-year period beginning with fiscal year 1982, subject to the determination by the Secretary at the end of each fiscal year of operation of a Center that the recipient has complied with the assurances contained in the application for the grant.

"(b) The responsibilities of any Center funded under this part shall be to—

"(1) identify sources of courseware materials and provide information about such materials to interested parties;

"(2) develop courseware materials for use in areas in which available courseware materials are inadequate;

"(3) identify and develop curriculum materials for instructing students at all educational levels in the uses of computers;

"(4) provide special teacher training and demonstration computer systems to schools at all educational levels that have a large proportion of minority students;

"(5) develop methods for enabling handicapped individuals to use computers for communication and educational purposes;

"(6) conduct programs demonstrating the various educational uses of computers which shall include, but not be limited to—

"(A) the provision of computers in the classroom for student use which may include as many as one computer per four students,

"(B) the establishment of a laboratory that uses computers to simulate live experiments, and

"(C) the establishment of a computer library that would allow students to borrow personal computers for use outside the classroom;

"(7) assess the relative quality and merits of commercially available microcomputers and disseminate such assessments to educators;

"(8) monitor new developments in educational technology, including microcomputers and video disc systems, and disseminate information about such developments to educators,

"(9) develop teacher training materials, including computer programs, films, slides, pamphlets, and audio and video cassettes, that will—

"(A) instruct educators about personal computers and their uses to enable them to determine the amount of financial resources and personnel to commit to the use of computers in their educational system,

"(B) instruct educators in the methods of using computers to enhance the learning experiences of their students in the classroom, in laboratories, and at home, and

"(C) instruct teachers in computer programing and in the development of courseware materials;

"(10) establish a demonstration laboratory to exhibit examples of personal computer systems and courseware materials to enable educators to personally observe the operation of such computers and courseware materials;

"(11) publish a periodic newsletter to disseminate information on computers, computer training programs, and courseware materials;

"(12) assist Congress and interested Federal agencies in developing a program for establishing regional centers for personal computers in education, that shall include, but not be limited to, appropriate goals and designs for such centers;

"(13) solicit from subscribers to the newsletter established under paragraph (11) of this section information concerning their computer education needs;

"(14) assist Congress and Federal agencies in identifying areas in which Federal funding will accelerate the educational impact of emerging computer technologies;

"(15) undertake any studies requested by Congress or Federal agencies relating to educational uses of computer technology;

"(16) establish a mechanism to inform the computer industry of the computer needs of the Nation's educational system and to receive from the computer industry information concerning recent developments in computers;

"(17) monitor developments in the area of intercommunication among users of personal computers and devise means of utilizing intercommunication to inform educators of the potential uses of personal computers;

"(18) assist interested local libraries in establishing programs to provide personal computers and video disc systems to the public; and

"(19) establish a model community personal computer center in one local shopping mall which shall—

"(A) provide a site for field trips by groups of local students,

"(B) provide demonstrations of the educational uses of personal computers to patrons of the mall,

"(C) conduct courses for community residents on the operation of personal computers, and

"(D) provide computer programs and books, magazines, and other information about computers on loan to the public.

"APPLICATION

"SEC. 394. Any person or entity desiring to receive a grant under this part shall submit to the Secretary an application for the establishment and operation of a Center. Applications under this section shall be submitted at such time, in such form, and containing such information as the Secretary shall prescribe. An application shall not be approved unless it—

"(1) provides that the Center will be administered by, or under the supervision of, the applicant;

"(2) provides for the performance of the responsibilities described in section 393(b);

"(3) sets forth policies and procedures that will ensure adequate evaluation of the performance of the Center;

"(4) provides for such fiscal control and fund accounting procedures as may be necessary to assure proper disbursement of and accounting for Federal funds paid to the applicant under this part; and

"(5) provides for making an annual report and such other reports in such form and containing such information as the Secretary may reasonably require and for keeping such records and affording such access thereto as the Secretary may find necessary to assure the correctness and verification of such reports.

"REPORT

"SEC. 395. Each recipient of a grant provided under this part shall transmit a final report to the President not later than January 1, 1987. The final report shall contain a detailed statement of the activities of the Center operated by the recipient, together with recommendations of ways to use personal computers to improve the educational system of the United States.

"DEFINITIONS

"SEC. 396. For purposes of this part—

"(1) the term 'courseware materials' means educational materials for use with personal computers and includes, but is not limited to, computer programs and student-teacher workbooks that provide—

"(A) simulated laboratory experiences in the natural and social sciences,

"(B) discovery learning in mathematics,

"(C) drill and practice in communications, mathematics, and science,

"(D) educational games that provide learning experiences, and

"(E) materials to develop problem-solving skills in mathematics and science;

"(2) the term 'microcomputer' means a digital computer constructed primarily of microelectronic components;

"(3) the term 'personal computer' means a microcomputer that is portable, costs less than $2,000, and needs only an electrical outlet for use; and

"(4) the term 'computer' means a microcomputer or a personal computer.

"AUTHORIZATION OF APPROPRIATIONS

"SEC. 397. There is authorized to be appropriated to carry out the provisions of this part $4,000,000 for the fiscal year ending September 30, 1984. Sums appropriated under this section shall remain available until September 30, 1986.".

I

98TH CONGRESS
2D SESSION

H. R. 4628

To establish a National Educational Software Corporation to promote the development and distribution of high-quality, interactive, and educationally useful computer software, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

JANUARY 24, 1984

Mr. GORE introduced the following bill; which was referred jointly to the Committees on Education and Labor and Science and Technology

---

A BILL

To establish a National Educational Software Corporation to promote the development and distribution of high-quality, interactive, and educationally useful computer software, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE

SECTION 1. This Act may be cited as the "National Educational Software Act of 1984".

FINDINGS

SEC. 2. The Congress hereby finds—

(1) that computers can play a valuable role in enhancing the quality of education in this Nation;

(2) that high-quality, interactive, and educationally useful software is essential to enable the tremendous educational potential of computers to be realized;

(3) that the vast majority of educationally oriented computer software now available is of less than adequate quality; and

(4) that a national effort is needed to encourage the development of high-quality, interactive, educationally useful software for our Nation's schools.

ESTABLISHMENT OF CORPORATION

SEC. 3. (a) There is established within the Government a National Educational Software Corporation (hereafter in this Act referred to as the "Corporation").

(b) The Corporation shall be operated under the general direction and supervision of a board of directors which shall consist of—

(1) the Secretary of the Department of Education, the Director of the National Science Foundation, and the Director of the Office of Science and Technology Policy, or their designees for this purpose; and

(2) twelve individuals appointed by the President with the advice and consent of the Senate as follows:

(A) four individuals shall be individuals engaged in the teaching profession who, as a group, teach at elementary and secondary schools and institutions of higher education;

(B) three individuals shall be individuals involved in the administration of educational institutions;

(C) three individuals shall be individuals who are experts in the application of computer technology to education; and

(D) two individuals shall be individuals who are experts in the venture financing of high technology companies.

(c) Except for the individuals specified in subsection (b)(1) of this section, no individual who is a full-time officer or employee of the Federal Government may be appointed to the board of directors of the Corporation. A vacancy in the board shall be filled in the manner in which the original appointment was made. Members of the board may be removed by the President for good cause.

(d)(1) Except as provided in paragraphs (2) and (3) of this subsection, those members of the board of directors appointed pursuant to subsection (b)(2) of this section shall be appointed for terms of six years.

(2) Of the members first appointed pursuant to such subsection—

(A) three shall be appointed for a term of six years;

(B) three shall be appointed for a term of five years;

(C) three shall be appointed for a term of four years; and

(D) three shall be appointed for a term of three years.

(3) Any member of the board of directors appointed to fill a vacancy occurring before the expiration of the term for which his predecessor was appointed shall be appointed only for the remainder of such term. A member may serve after the expiration of his term until his successor has taken office.

(e) The President shall appoint the Chairman of the board of directors from among those members appointed pursuant to subsection (b)(2) of this section.

(f) The board of directors shall meet at the call of the Chairman or a majority of its members. Ten members of the board shall constitute a quorum. A majority vote of the board shall be necessary to approve the actions of the Corporation under this Act. Members of the board may vote by written proxy or written assignment of proxy.

(g) The board of directors shall appoint an executive director who shall be responsible for the management and administration of the Corporation.

(h) Members of the board of directors appointed by the President shall each be paid at a daily rate equal to the daily equivalent of the rate of basic pay payable for grade GS–18 of the General Schedule and shall be entitled to travel expenses and a per diem in lieu of subsistence in accordance with subchapter I of chapter 57 of title 5, United States Code.

(i) Members of the board of directors who are full-time officers or employees of the Federal Government shall receive no additional pay by reason of their service on the board.

PRINCIPAL FUNCTIONS OF THE CORPORATION

SEC. 4. Subject to the availability of appropriations therefor, the Corporation shall—

(1) develop criteria for the selection of high-quality, interactive, and educationally useful computer software;

(2) secure investment capital for projects, selected by the Corporation as warranting its assistance, to develop such software;

(3) make appropriate and reasonable investments in projects for the development of such software, subject to the limitations contained in this Act;

(4) enter into contracts and make grants to assist in the development of such software;

(5) establish, or provide for the establishment of, a clearinghouse to disseminate information on such software to educational institutions and agencies; and

(6) engage in such other operations and activities as the board of directors determines to be necessary and appropriate to encourage the development and use of such software.

GENERAL AUTHORITIES OF THE CORPORATION

SEC. 5. In carrying out its functions under section 4, the Corporation is authorized—

(1) to adopt and use a corporate seal, which shall be judicially noticed;

(2) to sue and be sued in its corporate name;

(3) to adopt, amend, and repeal bylaws governing the conduct of its business and the performance of the powers and duties granted to or imposed upon it by law;

(4) to acquire, hold or dispose of, upon such terms and conditions as the Corporation may determine, any

property, real, personal, or mixed, tangible or intangible, or any interest therein;

(5) to invest funds derived from fees and other revenues in obligations of the United States and to use the proceeds therefrom, including earnings and profits, as it shall deem appropriate;

(6) to indemnify directors, officers, employees, and agents of the Corporation for liabilities and expenses incurred in connection with their Corporation activities;

(7) to purchase, discount, rediscount, sell, and negotiate, with or without its endorsement or guaranty, and guarantee notes, participation certificates, and other evidence of indebtedness (provided that the Corporation shall not issue its own securities);

(8) to make and carry out such contracts and agreements as are necessary and advisable in the conduct of its business;

(9) to exercise the priority of the Government of the United States in collecting debts from bankrupt, insolvent, or decedents' estates;

(10) to determine the character of and the necessity for its obligations and expenditures, and the manner in which they shall be incurred, allowed, and paid, subject to provisions of law specifically applicable to Government corporations; and

(11) to take such actions as may be necessary or appropriate to carry out the powers herein or hereafter specifically conferred upon it.

PROVISIONS CONCERNING INVESTMENTS BY THE CORPORATION

SEC. 6. (a) Any investment made by the Corporation under section 4(3) in a project for the development of high-quality, interactive, and educationally useful software must be based on a finding by the board of directors that—

(1) the proceeds of the investment will be used only to cover the initial capital needs of the project, except as otherwise specified in this Act;

(2) the project has a reasonable chance of success;

(3) the Corporation's investment is necessary to the success of the project because funding for the project is unavailable in the traditional or venture capital markets, or because funding has been offered on terms that would substantially hinder the success of the project; and

(4) there is a reasonable possibility that the Corporation will recoup at least its initial investment.

(b) No investment shall be made by the Corporation unless the board of directors determines that a reasonable, good faith effort has been made to secure a professional investor, in lieu of the Corporation, to make an adequate investment in the project, and that such effort was unsuccessful. Subject to the requirements of this Act, nothing shall prohibit the Corporation from making an investment in a project as a coventure with professional investors if the Corporation determines that its investment is appropriate to the project's success.

(c) The Corporation shall not make any investment by which it exercises or has the power to exercise any voting rights under an equity security.

(d) For purposes of this section, the term "professional investor" means any bank, bank holding company, savings institution, trust company, insurance company, investment company registered under the Investment Company Act of 1940, pension or profit-sharing trust or other financial institution or institutional buyer, licensee under the Small Business Investment Act of 1958, or any person, partnership, or other entity of whose resources a substantial amount is dedicated to investing in securities or debt instruments and whose net worth exceeds $250,000.

AUTHORIZATION OF APPROPRIATIONS

SEC. 7. There is authorized to be appropriated to carry out this Act $15,000,000 for each of the fiscal years 1985, 1986, and 1987.

Chairman **PERKINS**. We have a distinguished panel of witnesses today. Our first witness is the Honorable Albert Gore, Jr., sixth District, Tennessee, accompanied by Chancellor Joe B. Wyatt, Vanderbilt University, Nashville, TN.

I am delighted to welcome you here, Congressman Gore and you proceed in any manner you prefer.

[Prepared statement of Albert Gore, Jr., follows:]

PREPARED STATEMENT OF HON. ALBERT GORE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TENNESSEE

Mr. Chairman, I am grateful to you and the subcommittee for holding this hearing on a matter which is becoming one of the most important issues in education. This country must rapidly accelerate the speed with which our young people are learning to use computers, and using computers to learn. More specifically, we must provide the hardware and software that will make that objective possible.

I believe that my bill, H.R. 4628, which establishes a National Computer Education Software Corporation, and those of my colleagues, Mr. Wirth and Mr. Downey, are significant steps in the right direction-toward improved educational opportunities at every level, toward enhanced job prospects for our graduates entering a rapidly changing economic environment, and toward a national improvement in productivtiy and international competitiveness.

Last September I held two days of hearings in my Science and Technology Subcommittee on Investigations and Oversight on the issue of computers in education. I will be sending each member of the Committee a copy of the final reports of those hearings, but want to take a moment to recount what we learned.

The testimony was startling. Although computers have more potential to improve education than any invention since writing, that potential is not being realized at all.

There are three reasons why it is not: 1) unavailability of hardware and equitable distribution of hardware; 2) inadequate training of teachers in how to use computers most effectively; and 3) most importantly, the lack of high-quality educational software. It is this third problem that H.R. 4628 is designed to address.

The Secretary of Education, Dr. T. H. Bell, provided dramatic testimony about the grossly inadequate software used in most schools. He testified that practically all of the educational software now available is no more than "electronic page-turning," consisting of low-level, drill-and-practice programs; that many academic disciplines have virtuallly no software programs; and that incompatibility of different software and hardware language systems threaten any speedy improvement in what is acknowledged to be a haphazard use of educational computer tools.

Further complicating this problem is the widely diffused, uneven marketplace, which is essentially made up of thousands of necessarily unconnected local school systems. Local educators and administrators are legitimately wary of investing large sums of local school budgets in newfangled high technology that has been touted as the cure for all their instructional problems. So what is made available is the lowest common denominator in educational software. The few good programs are hard to find and even harder to translate into different formats.

Simply put, our schools are being swept up in a tidal wave of technology without any idea of how to make wise use of it.

My bill is designed to make a modest, but, hopefully, a significant improvement in the availability of educational software. It establishes a National Educational Software Corportion, made up of government and private corporate and institutional representatives. The Corporation would have the authority to provide venture capital support to high-quality, interactive educational software projects which have great promise but inadequate private funding.

These software ventures would be expected to provide the Corporation a return on its investment, with profits made available for new projects. In that regard, we would expect the government support to set up the Corporation—$15 million in my bill—to become a revolving fund and essentially have a zero cost to the government.

However, the educational benefits from this modest investment should be enormous, in the form of innovative new computer tools for teachers and students throughout the country.

There is a clearly successful precedent for government participation as a provider of capital for private technology ventures. The Corporation envisioned in my bill is based on a model begun several years ago by the Massachusetts Legislature, which set up the Massachusetts Technology Development Corporation to stimulate new high technology companies and new ventures in that State. To tell you more about that model, and other aspects of the potential for our National Educational Software Corporation, I want to introduce, at this time, your next witness. Joe B. Wyatt is currently Chancellor of Vanderbilt University in Nashville, Tennesseee. He provided insightful testimony during my hearings last September and, subsequently, has worked closely with me to develop H.R. 4628, to establish the Software Corporation.

Prior to coming to Vanderbilt in 1982, Chancellor Wyatt was Vice-President for Administration of Harvard University. During his tenure he was a senior lecturer in computer science, and a standing member of the Faculty of the Institute for Educational Management. In 1976, he was appointed to the board of the Massachusetts Technology Development Corporation, later became its vice-chairman and chairman of the Corporation's Investment Advisory Committee. I think you will agree that Chancellor Wyatt brings extraordinary credentials to the discussion about how to improve the use of computers in our schools. I am extremely pleased to introduce Chancellor Joe Wyatt to the Committee this morning.

STATEMENT OF HON. ALBERT GORE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TENNESSEE, ACCOMPANIED BY CHANCELLOR JOE B. WYATT, VANDERBILT UNIVERSITY, NASHVILLE, TN

Mr. GORE. Thank you very much, Mr. Chairman. I appreciate your courtesy and that of Congressman Miller for hearing us this morning. This matter is one of extreme importance to the country and I am very grateful that this subcommittee has the leadership and participation on this matter.

This country has a tremendous interest in accelerating the speed with which our young people learn to use computers and the speed with which they use computers to learn. More specifically, we must provide the hardware and software that will make that objective reachable.

This bill, H.R. 4628, would establish a National Computer Education Software Corp. The three bills you mentioned—mine and those offered by Mr. Wirth and Mr. Downey, together represent significant steps in the right direction toward improved educational opportunities at every level, toward enhanced job prospects for our graduates entering a rapidly changing economic environment and toward a national improvement in productivity and international competitiveness.

Last September, my Subcommittee on Investigations and Oversight of the House Science and Technology Committee held 2 days of hearings on the issue of computers in education. I will provide each member of this subcommittee and your full committee a copy of the final report of those hearings.

Let me take a moment to tell you what we found out. The hearings were based on two assumptions: One, that computers offer a greater potential to improve education than any other technological development in history; two, that that potential is simply not being realized We found that there were essentially three reasons why the potential is not being realized today. First, the unavailability of hardware and the inequitable distribution of hardware. There are not enough computers in schools, stated simply. Wealthy school districts are much more likely to have computers than lower income school districts. That's the first obstacle for reaching our objective.

The second obstacle is inadequate training of teachers in how to use computers most effectively in the classroom. The third obstacle—and in my view the most serious obstacle—is the lack of high quality educational software.

The first two obstacles I mentioned are being addressed in other bills—Congressman Wirth's bill, Congressman Downey's bill, the bill introduced earlier by Congressman Stark that passed the House in the last Congress and still is awaiting action in the Senate. Those are designed to address the first two problems.

The third problem, the lack of high quality educational software, is what this bill is focused on. A lot of our testimony centered on this problem, and it was startling. Our lead-off witness was the Secretary of Education, T.H. Bell. He said that more than 95 percent of the currently available educational software is almost totally useless. Many of the experts who testified before the hearing characterized the current educational software as essentially "electronic page-turning." That is, it puts a screen up for the student to read and when the student finishes reading that screen he goes on to the next screen. That has some value but not much because it doesn't take advantage of the special ability of computers to interact with students and actually teach. These programs are used for low-level drill and practice, but they are not anywhere near the value that we think that they should have.

We also found that many academic disciplines have virtually no software programs at all—not even the electronic page-turning kind. We also found a tremendous incompatibility between different software and hardware language systems and that incompatibility threatens to thwart any speedy improvement in this situation.

One of our witnesses described this problem in an interesting way. You are familiar with the statement, Mr. Chairman, that software is to computers as records are to phonographs. A record player doesn't do you much good if you don't have a record to play on it. Well, a computer doesn't do you much good, if you don't have any software to play on it.

One of our witnesses used that analogy and took it a little bit further. He said, "Imagine a music industry where the record players available played not only 33⅓ rpms, 78 rpms, and 45 rpms, but you had 100 other rpm categories and no single record player would play more than one rpm record and they all had a roughly equal small slice of the market. That's not too different from what the educational computer market looks like today. As a result, someone who wants to produce a high quality educational program can look forward to marketing that program in only a tiny slice of the total market and, as a further result, the most talented writers of software are not attracted into the educational market. They are going toward the business market mostly.

Moreover, we found that when those companies that have a larger position in the market find a good software product, they often tend to design its architecture or its basic design in a way that locks it in to their machine, to encourage school districts that make an initial investment in their hardware to stay with their machines when they get ready to purchase more or trade up to the next generation.

That makes it very hard to take those few good programs and translate them into the other formats that other school districts have. Well, simply put, our schools are being swept up in this tidal wave of new technology and they are finding it very difficult to make wise and constructive use of the new technology.

This legislation is designed to make a modest, but hopefully, significant improvement in the availability of high quality educational software. It establishes a National Educational Software Corp. made up of government, private, corporate and institutional representatives.

The corporation would have the authority to provide seed money, or venture capital support, to high quality, interactive educational software projects which have great promise but inadequate funding. These software ventures would be expected to provide the corporation a return with profits made available for new projects. We would expect and hope this corporation to have, over the long term, a zero cost to the Government. The educational benefits should be enormous in the form of innovative, new computer tools for teachers and students throughout the country.

The precedent for this mechanism was the Massachusetts Technology Development Corp. which was set up in the State of Massachusetts to stimulate new high technology companies and new ventures in that State. Essentially, none of these projects could go forward unless they were able to attract private venture capital because the bulk of the funding would come from the private sector.

The board of this corporation, however, would evaluate the proposals submitted against educational criteria, against the ease with which they could be translated into different formats and then give its imprimatur or seal of approval. Why would venture capitalists be more willing to put money into a project of that kind? Simply because the evaluation conducted by this board would lower their risk threshold. This model has worked with tremendous success when it was tried in Massachusetts.

At this time, I want to introduce to you Chancellor Joe B. Wyatt. He is now Chancellor of Vanderbilt University. He was at Harvard University at the time he served on the Massachusetts Technology Development Corp. and he testified during my subcommittee's hearings last September. Subsequently, Chancellor Wyatt and I have worked closely together to develop this legislation and he has provided critical ideas necessary to bringing this bill before you today.

During his tenure at Harvard, he was a senior lecturer in computer science and a standing member of the faculty of the Institute for Educational Management. In 1976, he was appointed to the board of the Massachusetts Technology Development Corp. and later became its vice chairman and chairman of the corporation's Investment Advisory Committee.

I think you will agree that Chancellor Wyatt brings extraordinary credentials to this discussion of how to improve the use of computers in our schools. I am pleased to introduce to you at this time Chancellor Wyatt.

Chairman PERKINS. Before he starts, Mr. Gore, are you rushed for time?

Mr. GORE. No, sir.

Chairman PERKINS. Can you sit in with Mr. Downey and Mr. Wirth later on this morning? They are here for the same purpose.

They have got their own bills and I would like to get this thrashed out today.

Mr. GORE. All right. Fine.

Chairman PERKINS. Go ahead, Mr. Wyatt.

[Prepared statement of Joe B. Wyatt follows:]

PREPARED STATEMENT OF JOE B. WYATT, CHANCELLOR, VANDERBILT UNIVERSITY

Mr. CHAIRMAN, I am most pleased to have been invited here to add my strong support and enthusiasm for a legislative initiative by Congressman Gore, which I helped draft, that enables the private sector and government to work together on perhaps the most exciting new opportunity in the future of education. I speak of the use of computers and related technology as an adjunct to the teaching and learning process.

There is broad support today for the hypothesis that computers and related technology, in the hands of informed and able teachers, can improve learning considerably. And there is general agreement that technology's dramatically improving performance coupled with declining costs will encourage its widespread distribution and use in American schools at all levels. But as Congressman Gore has already told you, there is also a general consensus that the development of imaginative and effective software for the educational use of computer technology, is seriously lacking. Teachers, principals, school superintendents, college professors and administrators, and the Secretary of Education all agree with this.

The most effective educational software is interactive and therefore responsive to the level and pace of individual students. Such software, implemented in computer systems with optical disk storage, graphic and text overlay displays, and voice response and recognition units, would dramatically increase the interaction between teacher and students. These systems do not suggest that students should just sit alone, confined to stare at a video display tube for their learning. Indeed, the most successful application involve the active use of the technology by the teacher as an adjunct to lectures and demonstrations in the classroom as well as in small group discussions among students and in individual conferences between teacher and student.

The best of the few interactive educational software systems that do exist have required the devotion of considerable effort and talent. Each is the product of a gifted teacher and a small group of specialists working in close harmony for extended periods of time. Very often, substantial technological resources are also required. Forming and nurturing such small groups is indeed a fundamental problem. And even after good software is developed, the authors often do not understand or are disinterested in the issues of marketing, distribution, and support so necessary for widespread use in education, Thus, there is need for special efforts to encourage the development of superior educational software and to provide strong incentives for its widespread dissemination and use. Experience from the successful transfer of high technology hardware from the laboratory to the marketplace in this country has suggested a method to encourage viable efforts to form and flourish.

House Resolution 4628 proposes the establishment of a National Educational Software Corporation. The concept is based on a very successful model for the stimulation of investment in small, high technology companies in Massachusetts. The Massachusetts Technology Development Corporation (MTDC) was founded in 1978. At that time, such companies were languishing in Massachusetts, the birthplace of high technology. In only five years, it has become the lead participant in more than $37 Million of venture financing for twenty-two highly innovative young companies. Beginning with a capital fund of $1.5 Million, MTDC has invested $4 Million in companies and attracted another $33 Million in investments in the same companies from conventional private sector sources. In other words, every dollar of public investment has produced over $6 of new private sector investment in these small companies producing technology.

The National Educational Software Corporation proposed by HR 4628 would be established and modestly capitalized for the purpose of investing in start-up and add-on businesses specializing in interactive educational software. Candidate businesses would submit business plans describing the software and the approach for developing, marketing, and distributing the software to both public and private educational institutions. A twelve member Board of Directors, composed of educators, business executives, venture capitalists, and government officials would appoint a small staff of investment analysts headed by an executive director, to review and screen proposals as well as provide advice to formative businesses. In the final process of review for proposals deemed particularly strong, the investment staff will seek private co-investors including private venture capital firms, banks, and other "sophisticated investor." Those proposals considered to be sound both th the investment staff and a suitable co-investor, would be recommended to the Board for approval. The Board then would either approve, reject, of reject with suggestions for refinement, each of the proposals it received. For those investments approved by the Board, financing could take the form of secured debt, convertible debt, and equity in whatever mix is considered appropriate for the particular investment. The terms of the investment made by the Corporation must be equal to the investment made by the private co-investor. Although its principal purpose is investment, the Corporation also will be authorized to make some limited grants, in aggregate less than five percent of its annual budget, to fund small projects related to interactive educational software. The general objective of these small projects will be to assess specific areas of need, valuate the effectiveness of certain computer-based education systems, and otherwise stimulate the development of imaginative educational software.

Probably the most novel aspect of the methodology proposed in HR 4628 is that the National Educational Software Corporation would become an equity investor in businesses, in the same manner that has been so successfully employed by the Massachusetts Technology Development Corporation. In other words, the Corporation will benefit monetarily from successes of its investments and, over a period of time, might become self-sufficient. If the Corporation eventually fulfills its purpose to the extent that it is no longer needed to stimulate educational software development, it could be sold to become a private enterprise, or it could liquidate its investments in the public and private financial markets.

It is important to note that the Corporation is not a research agency. It will not be dispensing research grants, but will be an investor in business ventures that propose promising educational software projects. It will normally function as the lead investor for ventures that submit outstanding business plans for the development, implementation, and marking of educational software materials. It is expected that the Corporation would maintain no interest larger than its co-investors, and would normally allow the co-investor to represent the Corporation on the boards of the businesses in which investments are made. However, it would retain the right to be an observer at any board meetings and would also retain the right to elect to take a board seat, if special circumstances warrant in the opinion of the Corporation's board of directors. In order to assure the successful continuation of businesses that show promise after start-up, the Corporation will have the authority to participate in follow up investments, to add capital, and to expand participation in promising ventures.

For purposes of evaluating its own investment opportunities, the Corporation will develop selection criteria and establish an information clearinghouse function related to the state-of-the-art in educational software development. It is not intended, however, for the Corporation to develop criteria for all software products or become an information clearinghouse for matters unrelated to investment opportunities. Moreover, the Corporation would make no investments alone. It would be required that a private venture capitalist join each investment on a co-equal basis; that is, a private venture capitalist would invest at least as much as the Corporation, on an equivalent basis, before the investment could go forward. It is not expected, however, that a potential investment would have been refused all capital for a project before the Corporation could consider its participation.

Nearly everyone agrees that dramatic improvement in the quality and productivity of education is a national priority, a priority that concerns the largest cities and the smallest communities in America. Several national Commissions have recently declared the state of mathematics and science education to be a national crisis. Reading and writing skills have also declined to the extent that one authoritative study suggests that high school and college graduates of today are less well educated than their parents. It is likely that an immediate contribution to the solution of this problem could result from the development and widespread use of interactive educational software, particularly at the high school level.

Some important progress is already being made at the college level. For several years, a score of colleges have augmented their time-shared computer systems with interactive educational software. With the advent of microcomputers, many other colleges are beginning to develop interactive software for in-house use in teaching mathematics and science, including calculus, statistics, biology, and chemistry. And some of the most exciting new developments apply interactive software in the arts and humanities, teaching expository writing, law, and music composition. But most of these experiments are quite new, and very few examples of use exist outside the author's own school. The infrastructure for further developing, testing, marketing, distributing and using the best of these software efforts is embryonic at best. And there will be resistance to change in the schools that will be overcome only through successful experience with such an infrastructure. Successful models are much too few in number.

Less a criticism of past practice, more a realization that education becomes increasingly complex and demanding as our society advances both culturally and scientifically, HR 4628 represents an important step toward harnessing the strength of the federal government with the imagination of gifted educators and the entrepreneurial energy of the private sector to address one of the most important problems of the 20th century, perhaps the 21st century as well.

Joe B. Wyatt was a founding Director of the Massachusetts Technology Development Corporation, Vice Chairman of its Board of Directors and Chairman of its Investment Advisory Committee, while at Harvard University. He is now Chancellor of Vanderbilt University in Nashville, Tennessee.

STATEMENT OF CHANCELLOR JOE B. WYATT, VANDERBILT UNIVERSITY, NASHVILLE, TN

Mr. WYATT. Mr. Gore, thank you very much for the introduction. Mr. Chairman, I thank you very much for inviting me here to speak on behalf of this particular piece of legislation which I helped draft.

There is certainly broad support today for the notion that computer and related technologies can provide a breakthrough in the delivery of education and in the teaching and learning process generally. We see that technology developing very rapidly from the standpoint of hardware to the point at the present time where we are able to interface optical disk storage units and other devices to microcomputers. That will allow imaginative and effective use for teachers and for students acting in concert with one another.

The most effective educational software is interactive. That is, it is able to simulate the interaction, one-on-one, between teacher and student. It is able not only to simulate that, but provide materials in a way that is provocative, is interesting, and is quite useful. However, none of that functions without the development of computer programs. That is the area that we refer to as computer software. The graphics, the video disks, the voice response and recognition units—none of that can function without creative efforts on the part of teachers and specialists in these technologies.

What we have here in essence is a problem of technology transfer. We know that in universities today these devices and their prototypes are being used to develop early on material for use in teaching in colleges and universities. We see this used in areas ranging from medicine, statistics, calculus, law, to teaching computer science itself.

The idea is to provide a vehicle by which the best of these efforts can move from laboratory to classroom use in the schools. That is the basis for the idea of the educational technology corporation that would provide venture capital for small businesses that are engaged in this transfer from laboratory to use.

Let me tell you a few words. It is an unusual structure and one, in fact, when Governor Dukakis in Massachusetts brought the idea to me a number of years ago, I was concerned about its value because it was my first opinion that only businesses that could not get financing in what one might refer to as legitimate venture capital areas would come to this enterprise. In fact, what we discovered in the several years of functioning of the Massachusetts Technology Development Corp., which, by the way, is still functioning, was that we acted as an interpreter, if you will, for the private venture capital area. We were operating with the objective of stimulating the startup of high technology companies in Massachusetts that had languished in the early 1970's. We were not restricting our activities to the computer software area. We looked at virtually any kind of technology business.

In 5 years, starting with a capital fund of $1.5 million, the Massachusetts Technology Development Corp. invested $4 million in startup companies in Massachusetts—about 22 of them—and attracted another $33 million in investments in these same companies from conventional private sector sources. In other words, for each dollar of public funds that were invested, we raised $6 of private sector investment in these companies. In addition to that, the Massachusetts Technology Development Corp. took an equity position in these companies so that, in fact, either through equity or debt, there was a true investment and funds are being returned as these are successful and grow and are put on the public market. The funds are actually replenished in the capital fund for reinvestment.

The first one of these investments did go into the public market a few months ago and an initial investment of $200,000 yielded an $800,000 return that goes back into the fund for reinvestment and other of these companies are in the very successful pipeline for the public market.

Now we have here a very specialized problem and that specialized problem is that there is virtually no formal marketplace for the development of educational software. Venture capitalists do not view, generally, the development of educational software as the kind of opportunity that they view the development of computer and related hardware. It is simply a marketplace that is undeveloped. It is my belief that the establishment of the National Educational Software Corp. would establish a market, would establish a vehicle by which venture capitalists could be brought to realize that what we have here is an opportunity of at least a decade and probably longer for investment in the transfer of the skills and technologies of educational software from the laboratory to the marketplace.

So the proposal is to establish this corporation very much along the lines and structure of the Massachusetts Technology Development Corp. Candidate businesses would submit business plans describing the software and their approach for developing, marketing, and distributing the software. This, by the way, is an area where the most creative people who are doing development very often—in fact, most often—lose interest—that is, in transferring their creation into the area of active use, maintenance, and operation.

Chairman **Perkins**. Let me ask you at that point. Have you had any reaction from private companies as to the establishment of this corporation?

Mr. **Wyatt**. Let me respond that in the case of the Massachusetts experiment, we had a very positive reaction. That is, all of the—no company that ever registered an opinion on the matter with either the corporation or the Governor—two Governors—objected to the operation of this enterprise and, in fact, found it salutory to the development of the high technology industry generally. I have had no negative reaction on this proposal myself. Perhaps Congressman Gore has had some.

Mr. Gore. If I may respond, Mr. Chairman. I have had a good bit of extremely positive reaction from small computer software companies who have expressed real interest, have asked for copies of the legislation, have asked for private meetings to describe its intent and purpose and two of them have said that they are eagerly waiting for this kind of opportunity. I think that it would be viewed very positively in the business community and just as importantly, like the Massachusetts Technology Development Corp., the venture capital market is eagerly awaiting some way to get a better understanding of how to find their way through this maze. I think we would get a very positive reaction.

Chairman Perkins. Now, Albert, I am wondering whether some of these private companies are thinking that this federally funded corporation may stifle competition by favoring one company over another. Have you gotten any reaction like that?

Mr. Gore. Well, they shouldn't think that because none of the proposals approved by this board would be able to go forward until the private venture capital market had come in and participated in it to a much larger degree than the Government.

Now, if a company didn't want or feared that it wouldn't get through this process it has free reign to go to the venture capital market on its own, go to the customers on its own. In any event, the projects coming out of this process would have to go to the customers and compete with other businesses who hadn't participated in the corporation's process.

Chairman Perkins. Excuse me for interrupting you, Mr. Wyatt. Go ahead.

Mr. Wyatt. That's quite all right. I think you are asking important questions and questions that each of us have had about this matter as we go forward. But I do believe they can be answered very satisfactorily and the illustration that we are using—in fact, model—answers those questions all in the affirmative.

I would like to say that perhaps the most novel aspect of this methodology is that this corporation would become an equity investor in these businesses in the same manner as that employed by the Massachusetts Technology Development Corp. In fact, if the corporation eventually fulfills its purpose, it is felt that the market has been established that the venture capital activity is operating on its own, then this enterprise could be liquidated and its investment sold in the public or private financial market.

Now, it's important probably to note some things that this corporation is not. It is not a research agency to replace any of the existing research agencies. It won't be dispensing research grants. It will be an investor in business ventures, a coinvestor with private venture capitalists. It would normally function as the lead investor. That is, doing the initial evaluation, filtering out those proposals that don't look sound for one reason or another or don't look like exactly the right kind of investment and, in fact, in the Massachusetts case, the ratios of proposals to business financed is something like 50 to 1. But it would, in fact, function as the lead investor so that when these businesses were presented to the conventional, private venture capital market, they would have, in fact, some reduction of risk so that it would maximize the opportunity for the private venture capitalists and the businesses, and most importantly, for the development of this educational software.

It is expected that the corporation would maintain no interest larger than its coinvestors and normally would allow the coinvestor to represent the corporation on the boards of the businesses in which investments are made. It certainly needs the right to take a board seat if the board of the corporation feels that's necessary.

It would also have the right to follow its initial investments to add capital and to expand participation. It obviously would need to have functions that would allow it to understand the marketplace, to do evaluations of software that already exists for its own purposes in the process of investment.

I think virtually everyone agrees that has looked at the problem that our educational system needs a dramatic improvement in productivity and quality and that, in some respects, technology can assist in that. But, in fact, we know from all of our experiments that no matter how much hardware we put out in the field and in the classroom, it is not going to function at all without software and it won't function well without very high quality and imaginative software and, for the the good of all of the legislation that is proposed to distribute hardware, we believe that strong efforts are behind schedule already in the development of educational software.

Now, some important progress is already being made at the college level. It is my own view that the transfer of this high quality material can occur most effectively initially at the high school level and that, in fact, calculus, statistics, biology and chemistry, prototypes are already available and, in fact, some of the most exciting new developments deal with topics in the arts and humanities, music composition, expository writing and the like. In fact, if we give the proper incentives, I believe that the bright minds in this country and the entrepreneurial instincts will respond to produce success.

So this is not a criticism of any of the current proposals for the distribution of hardware. Rather, it is, I believe, a necessary adjunct and one that will be required to harness the strength of the Federal Government with the imagination of gifted educators and, perhaps, most important of all, the entrepreneurial energy of the private sector to address perhaps what is the most important problem of this century and the turn of the century as well.

Chairman PERKINS. Thank you very much, Mr. Wyatt. Come around, Senator Lautenberg. Congressman Downey, you can come around to the table, too. Just stay right there, Al, if you will. We will hear from the Senator and then we will hear from you, Tom. Go right ahead, Senator Lautenberg.

STATEMENT OF HON. FRANK R. LAUTENBERG, A U.S. SENATOR, FROM THE STATE OF NEW JERSEY

Senator LAUTENBERG. Thank you, Mr. Chairman and members of the committee. Colleagues on behalf of an improvement in our educational system, I am pleased to be here and have the opportunity to share with you my views on computer education and I do offer my congratulations for recognizing the need for public discussion of the issue.

Computer education was one of the issues which I raised in my first speech in the Senate and it's one I have made a priority in the past year. Last September, I introduced a bill dealing with computer education. Last month, I introduced a revised and improved version of the bill, S. 2532.

This morning I would like to take a few minutes to discuss the basis of my interest in computer education and briefly to outline my legislative proposal. With your permission, Mr. Chairman, I would like to submit a longer statement for the record.

Chairman Perkins. Without objection, it will be inserted in the record.

[Prepared statement of Frank R. Lautenberg follows:]

Prepared Statement of Hon. Frank R. Lautenberg, a U.S. Senator From the State of New Jersey

I am very pleased to be here today and to have the opportunity to share with you my views on computer education. I congratulate you for recognizing the need for public discussion of this issue.

Computer education was one of the issues which I raised in my maiden speech in the Senate. It is one I have made a priority over the past year. Last September I introduced a bill dealing with computer education, and last month I introduced a revised and improved version of the bill, S. 2532. This morning I would like to take a few minutes to discuss the basis of my interest in computer education and briefly to outline my legislative proposal. With your permission, Mr. Chairman, I would like to submit a longer statement for the hearing record.

In the world economy of tomorrow, comparative advantage will be increasingly a function of innovation, adaptablility, and technical prowess. In this country we are blessed with a resourceful, independent, and creative people, and an economic system that rewards enterprise and initiative. With the right public and private policies, I believe that America can continue to be an effective competitor in the international marketplace.

Education, training, and research are essential ingredients to keep this country up to the mark. The rash of reports issued last year by the Commission on Excellence in Education, among others, show a serious concern that education in the U.S. is not equal to its task. Business leaders are worried too. A recent article by the chairman of the National Association of Manufacturers underlined this concern. He said, "For the first time in our history, we may produce a generation less educated than its predecessor. More alarmingly, it may possess the wrong skills—or simply inadequate ones—for the jobs of the future."

I share that concern, and would like to have us begin to make strides toward revitalizing and reinvigorating American education. Computer education will be a part of that process.

Educators need to begin to revise curricula and teach the skills so important to our changing economy. We must move away from rote learning to an emphasis on the collection, manipulation and use of data so important to an information-based economy. With careful planning, computer education can be integrated with the regular curriculum and enhance the teaching of all subjects.

One simple example can show the way that computers can improve the teaching of a traditional subject. One of the best ways to learn to write well is to do a lot of writing, and to revise, edit, and rewrite. Children, not unlike the rest of us, are reluctant to do the necessary rewriting. They do not want to have to copy the material over and over again. Word processing programs on computers have revolutionized this process. The basic text has to be typed into the computer only once. After that, changes are the only words that have to be newly typed. Suddenly rewriting becomes fun instead of a burden.

The bill, S. 2532, that I have introduced, along with Senators Dodd, Kennedy, Byrd and Moynihan, is the result of consultations with educators, parents, legislators, and other concerned citizens. Entitled the Computer Education Assistance Act, this bill provides for a competitive matching grant program. Among the highlights of the bill are an emphasis on careful planning for the incorporation of computer education in the school curriculum, and the importance of teacher training and research for the use of computers in schools.

The grant program is authorized for seven years, at $150 million a year for the first four years and such sums as necessary for an additional three years. It provides assistance to schools for planning, purchase of computer hardware and software, and in-service teacher training. The funds will be allocated to the states half on the basis of the school age population and half on the basis of the Title I formula, used for aid to disadvantaged school children.

Each state will make grants to local school districts. Applicants must assure that at least half the funds are targeted on schools with the greatest need for computers. School districts will be required to do some fairly extensive planning. The grants are to be matched, with the Federal share set at 75% and the non-Federal at 15%.

The bill provides $20 million a year for 7 years to the National Science Foundation to establish teacher training institutes. These institutes would provide more in-depth training for teachers than the in-service programs supported by grants under Title I of this bill.

Title III of S. 2532 authorizes funds for the National Science Foundation and National Institute of Education to provide assistance to organizations with the expertise for conducting research in computer education. They would evaluate existing material and develop new software and approaches to instruction.

My bill is similar in intent and structure to H.R. 3570, the bill introduced in the House of Representatives by Congressman Tim Wirth. The principal difference is in the grant program. The length and amount of the authorization in the two bills differ, as do the formula for distributing the funds to the states, the range of uses for which the funds can be used and the requirement for matching funds.

Congressman Wirth and I share the same goals. Clearly Congressman Wirth has taken a leadership role in the House along with this Committee and Congressmen Downey and Gore.

The grant programs in my bill and the Wirth bill differ in several respects. Let me explain the points of departure.

A number of studies of computer education have indicated that there is already a large difference in the availability of computers between well-off and poor districts. To address that equity, S. 2532 divides the grant funds among the states according to the proportion of poverty-level children as well as the general school-age population.

Under the grant program in my bill, funds can be used for the purchase of software as well as hardware, and for planning and in-service teacher training. The incentive and funding for planning is essential if computer education is to achieve its promise. Flexibility is also important, to allow schools to determine the proper mix of equipment and services that they need to develop the program they want to achieve. Schools that have enough computers can concentrate their resources on obtaining new software or on planning under the provisions of my bill.

Finally, S. 2532 requires a 25% matching share from grant recipients. This requirement will make the limited Federal funds go further. At the same time, poorer school districts will not be penalized because the matching share can be in services or donations, not just cash.

Computer education is no substitute for the 3 Rs. Putting computers in the classroom is not a panacea for the problems facing American education today. But, carefully designed computer education programs can clearly help. I am pleased that this committee recognizes the need to explore computer education. I hope that you will consider the legislation before you today and approve some form of assistance to help the schools enter the information age.

For the record I would like to submit a more detailed statement on S. 2532 which I made at the time it was introduced.

I will be glad to take any questions.

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Senate

By Mr. LAUTENBERG (for himself, Mr. Dodd, Mr. Kennedy, Mr. Byrd, and Mr. Moynihan):

S. 2532. A bill entitled the "Computer Education Assistance Act of 1984"; to the Committee on Labor and Human Resources.

COMPUTER EDUCATION ASSISTANCE ACT OF 1984

Mr. LAUTENBERG. Mr. President, the quality of American education is vital to the strength of our Nation. Our competitive position in the international economy is dependent on the ability of this country to produce well-educated, skilled, and creative workers. We must provide adequate resources to support top notch education of our children or be prepared to face the consequences. Many educational and industrial leaders have noted that our schools are falling behind in this task and that American education needs to be reinvigorated.

Computer education will be part of that reinvigoration process. Last September, I introduced legislation to establish a program of Federal assistance for schools to develop and improve computer education programs. I considered that bill, S. 1849, a working draft, subject to changes and improvements based on the suggestions and recommendations of educators, parents, legislators, and other concerned citizens. The bill that I am introducing today, along with my colleagues Senators Dodd, Kennedy, Byrd, and Moynihan is the result of the consultation process. It provides an improved path to the same goals articulated in the earlier version of the bill.

The Computer Education Assistance Act of 1984 continues to provide for a competitive grant program for planning, purchase of computer hardware and software, and teacher-training. It maintains the emphasis of S. 1849 on careful planning for the incorporation of computer education in the school curriculum.

The revised version of the bill also places emphasis on the importance of teacher-training and research for the use of computers in schools by drawing heavily on provisions in S. 1869, introduced last year by Senator Dodd and H.R. 3750, sponsored by Representative Wirth. One new section of the bill authorizes assistance for teacher-training institutes for elementary and secondary school teachers. The second new section of the bill provides for evaluation of computer hardware and software and the development of new software. The development of model instructional programs is also authorized.

At a time when new Federal expenditures are viewed with great skepticism, the kind of investment I am proposing will pay for itself many times over in a more productive citizenry. This investment is particularly important in schools with concentrations of poverty-level children who must not be deprived of the benefits of a modernized curriculum.

Computer education is no substitute for the three R's. Putting computers in the classroom is not a panacea for the problems of American education. But, carefully designed computer education programs can clearly help. This is why planning for the appropriate role of computer education is as important as buying new hardware and software. Thoughtful consideration must be given to the integration of computers into the curriculum. Computer education planners must first consider the overall goals for their school. Then, they must decide how computers can help them meet those goals. For some purposes, old, tried, and true methods will continue to be best. For other purposes, computers offer exciting possibilities for transforming the curriculum and the way it is taught.

Computers can be used by students in every subject in every grade. Students can use word processing programs to improve their writing by editing and revising more easily than they do now. They can learn to simulate "what if" situations in history classes so that they can understand more clearly the factors that affect human behavior and events. They can learn to use graphics to present data in a clear and meaningful way.

These uses of the computer in schools would go far beyond the teaching of computer literacy—a basic understanding of how a computer works and how to operate it—and programing. Computer literacy in school should be a beginning for computer education, not an end. Computers are more like pencils than books. As educators come to view computers in this way, as tools, they will begin using them in exciting and mind-expanding ways which is their true promise.

Thinking of computer education in broader terms will require coordination with curriculum planning. It is more than computer literacy, programing, and drill and practice programs. Once children learn how to operate a computer, they should have access to a wide range of application software for use in word processing, spread sheet analysis, and data base analysis, all of which can be used more generally than highly specialized instructional courseware.

Use of computers in schools is growing, but the need for Federal seed money is convincing. From the fall of 1980 to the spring of 1982, the number of microcomputers in public schools tripled. By early 1983 slightly over half of all public schools had at least one microcomputer.

However, although more than half the Nation's schools have at least one microcomputer, that is also the most that a large number of these schools have. Furthermore, little is known about the kind and amount of software or courseware that these schools are using with their computers.

A recent study, using January 1983 data, looked at the amount of time that microcomputers are actually used in schools. Looking only at the schools which reported at least one microcomputer, the survey found relatively few students obtaining access to the computers and for relatively short periods.

In elementary schools, 16 percent of the students used the computer in a week and 13 percent used one in secondary schools. The students who did use the computer spent 20 minutes a week in elementary schools and 45 minutes a week in secondary schools. These figures are for the median school, so some students had more access, some less.

To understand how small this amount of access is, consider what it would mean if students spent so little time with either pencil and paper or textbooks. The computer revolution in the schools is in its infancy, despite the enormous press coverage.

The Computer Education Assistance Act of 1984 will establish a program to assist States and local school districts in developing the ambitious computer education program that is needed. The program will authorize $150 million a year for the first 4 years and such sums as necessary for an additional 3 years for grants to schools for planning, acquisition of hardware and software, and teacher training. The funds will be allocated to the States half on the basis of the school age population and half on the basis of the title I formula, used for aid to disadvantaged schoolchildren. Each State will make grants to local school districts, which must assure that at least half the funds are used to serve title I eligible children and that funds are targeted on schools with the greatest need for computers.

School districts will be required to do some fairly extensive planning. This will include:

Setting goals for computer education in the schools and relating these goals to the overall educational objectives of the district;

Instructional priorities for the use of computers;

Schedules for placing computers in the elementary and secondary schools;

Criteria for selection of the hardware and software;

Planned revisions in the basis curricula of the schools designed to incorporate the use of computers; and

After school availability of the computers for use by parents and students.

The Federal grants are to be matched, with the Federal share set at 75 percent and the non-Federal at 25 percent. The non-Federal share can come from public or private sources, and may be in cash or kind. Local districts that can make arrangements with businesses and industries to donate equipment, personnel, or cash will not have to use their own funds for the matching share. Private school students would be eligible for assistance.

The bill provides $20 million a year for 7 years to the National Science Foundation for the establishment of teacher-training institutes. These institutes would provide more indepth training for teachers than the inservice training that the title I grants will support. Proper preparation of teachers is crucial to the success of a computer education program. These institutes will offer teachers an opportunity to learn about computers and the best methods for using them in the schools.

Evaluations of existing hardware and software and research and development on new software and instructional models will provide much of the underpinning for new programs of computer education. Title III of this bill authorizes the National Science Foundation to provide assistance to organizations that have expertise to carry out this research.

The planning requirement in this legislation is extremely important. Schools need to take a careful look at the role of computers in the total curriculum. They also need to consider such questions as whether to institute saturation programs at a limited number of schools or to provide computers in every classroom in a particular grade throughout the district. The bill does not set a goal for a specific ratio of students to computers or daily access time per student.

Plans are to include afterschool availability of computers for parents and children. This would permit parents and children to spend additional time working on the computers and gaining familiarity with them. Such afterschool programs would be especially helpful to those without access to computers at home. The children who do not have computers at home are very likely also attending schools which are least likely to have computers.

The benefits of the growth in computers are not evenly distributed among schools serving different socioeconomic groups. One study has found that 70 percent of the schools in more affluent areas had at least one microcomputer, while only 40 percent of the schools in poorer areas were so equipped. Another study found that twice as many students in well-to-do urban areas said that they had ever used a computer in school as students in disadvantaged urban areas. The number of computers in homes far exceeds the number in schools and the lion's share of those computers are in more affluent homes, including many with children. The additional exposure to computers in the home creates further disparity between rich and poor children.

The funds under the Computer Education Assistance Act of 1984 will be used in all schools, but at least half the funds will be targeted on schools with poverty-level children. Priority also is to be given to schools with the greatest need for computers. By establishing the targeting requirement and the priority for underserved schools, the bill aims to concentrate its resources in a way that benefits schools and children that are falling behind in computer usage. Funds will be allocated to the States half on the basis of school age children and half on the basis of the number of poverty-level children.

The grant funds can be used for planning, acquisition of hardware and software, and teacher-training. Each district will decide the mix of uses to which they will put their funds. This provides school districts with a great deal of flexibility.

In addition, the non-Federal matching share can be in-kind, such as donations of equipment or personnel services from private sources or from public agencies. This provides additional flexibility and an incentive for local school districts to involve the business community in their planning.

Mr. President, the program of planning and grant assistance for the purchase of equipment, training, and research authorized by this bill will provide Federal seed money for computer education programs. A great deal of flexibility is allowed and the result should be a better education for all children. This result is important for the growth and success of our children and our country.

Chairman **Perkins**. Go ahead.

Senator **Lautenberg**. Thank you. In the world economy of tomorrow, comparative advantage will be increasingly a function of innovation, adaptability and technical prowess. In this country, we are blessed with a resourceful, independent, creative people and an economic system that rewards enterprise and initiative. With the right public and private policies, I believe that America can continue to be an effective leader in the international marketplace.

Education, training and research are essential ingredients to keep this country up to the mark. The rash of reports issued last year by the Commission on Excellence in Education and others shows a serious concern that education in the United States is not equal to its task. Business leaders are worried, too. A recent article by the chairman of the National Association of Manufacturers outlined this concern. He said, "For the first time in our history we may produce a generation less educated than its predecessors. More alarmingly, it may possess the wrong skills or simply inadequate ones for the jobs of the future."

I share that concern and would like us to begin to make strides toward revitalizing and reinvigorating American education. Computer education will be a major part of that process. Educators need to begin to revise curricula and teach the skills so important to our changing economy. We have got to move away from rote learning to an emphasis on the collection, manipulation and use of data so important, critical, to an information-based economy. With the right kind of planning, computer education can be integrated with the regular curriculum enhancing the teaching of all subjects.

One simple example can show the way that computers can improve the teaching of a traditional subject. One of the best ways to learn to write well is to do a lot of writing and to revise and edit and rewrite. Children, not unlike the rest of us, are reluctant to do the necessary rewriting. They don't want to have to copy the material over and over again. Word processing programs, very simple, on computers have revolutionized this process. Basic text need only be introduced once. After that, the changes are simply the words that need revision. Suddenly, rewriting becomes fun instead of a burden.

I had a direct and personal experience in visiting a school in New Jersey. It's called the Computer Laboratory. Children about 8, 9, or 10 years-old were working with a series of terminals in front of them and when I asked one of the children what they were learning, he said to me, "Arithmetic." When I asked another child what she was learning, she said, "Spelling and English." The fact of the matter is that, as I see it, the computer ought to be more of a pencil than a book, a tool for conventional learning.

The bill I have introduced, S. 2532, along with Senators Dodd, Kennedy, Byrd, and Moynihan, is the result of consultation with educators, parents, legislators, and other concerned citizens. It's called the Computer Education Assistance Act and this bill provides for a competitive matching grant program. Among the highlights of the bill are an emphasis on careful planning for the incorporation of computer education in the school curriculum and the importance of teacher training and research for the use of computers in the schools.

The grant program is authorized for 7 years—$150 million a year for the first 4 years and after that such sums as necessary for the remaining 3 years. It provides assistance to schools for planning, purchase of computer hardware and software and inservice teacher training. Our focus, our emphasis, is on the planning and training phases. The funds will be allocated to the States, half on the basis of the school age population and half on the basis of the title I formula used for aid to disadvantaged schoolchildren.

Each State will make grants to local school districts. Applicants must assure that at least half the funds are targeted on schools with the greatest need for computers. School districts will be required to do fairly extensive planning. The grants are to be matched with the Federal share set at 75 percent and the non-Federal share at 25 percent. The bill also provides $20 million a year for 7 years to the National Science Foundation to establish teacher training institutes. These institutes would provide more indepth training for teachers than the inservice program supported by grants under title I of this bill.

Title III of S. 2532 authorizes funds for the National Science Foundation and the National Institute of Education to provide assistance to organizations with the expertise for conducting research in computer education. They would evaluate the existing material and develop new software and approaches to instruction. My bill is similar in intent and structure to H.R. 3570, the bill introduced in the House by Congressman Tim Wirth. The principle difference is in the grant program. The length and amount of the authorization in the two bills differ as do the formula for distributing the funds to the States, the range of uses for which the funds can be used and the requirement for matching funds.

Congressman Wirth and I share the same goals. Clearly, the Congressman has taken a leadership role in the House, along with this committee, and Congressmen Downey and Gore.

The grant programs in my bill and the Wirth bill differ in several respects. Let me explain the points of departure. A number of studies of computer education have indicated that there is already a large difference in the availability of computers between the well off and the poorer school districts. To address that inequity, S. 2532 divides the grant funds among the States according to the proportion of poverty level children as well as the general school age population.

Under the grant program in my bill, funds can be used for the purchase of software as well as hardware and for planning and inservice teacher training. The incentive and funding for planning is essential if computer education is to achieve its promise. Flexibility is also important to allow schools to determine the proper mix of equipment and services that they need to develop the program they want to achieve. Schools that have enough computers concentrate their resources on obtaining new software or planning under the provisions of my bill Finally, S. 2532 requires a 25-percent matching share from grant recipients. This requirement will make the limited Federal funds go further. At the same time, poorer school districts will not be penalized because the matching share can be in services or donations not just cash.

Computer education is no substitute for the three R's. Putting computers in the classroom is not a panacea for the problems facing American education today. But carefully designed computer education programs can clearly help. I am pleased that the committee recognizes the need to explore computer education. I hope that you will consider the legislation before you today and approve some form of assistance to help the schools enter and compete in the information age.

For the record, as I mentioned, I will be submitting a more detailed statement, which I made at the time the bill was introduced. I thank you, Mr. Chairman. I would be happy to answer any questions.

Chairman **Perkins**. Senator Lautenberg, let me ask you if you can remain with us a few minutes. I understand that Congressman Downey will have to leave very shortly and we want to get his statement and interrogate him a little bit.

Go ahead, Congressman Downey.

[Prepared statement of Thomas J. Downey follows:]

Prepared Statement of Hon. Thomas J. Downey, a Representative in Congress From the State of New York

Mr. Chairman, a year ago I appeared before this Subcommittee to present a statement in support of H.R. 1134, the bill which I introduced to create the National Centers for Personal Computers in Education. I appreciate the Subcommittee's continuing attention to this bill, and I welcome the opportunity to speak briefly about the bill this nmorning.

I believe that the need for this bill has increased since it was first introduced in 1978. Although no one doubts the importance of computers in education today, there is little concrete assistance given to school districts, administrators and teachers in overcoming the many problems they encounter in integrating computers into the schools of the Nation.

A recent study by the Center for Social Organization of Schools at The Johns Hopkins University found that though the use of microcomputers was growing in schools, most new microcomputers are being purchased by schools that already use computers. It would seem that the greatest difficulty lies in the initial introduction of computers into schools. Once that bridge is crossed, then further development of computer use is relatively easier. It would also appear that the gap between more affluent schools, that already have committed themselves to computers, and poorer schools, that may not have had the resources or the expertise to use computers, is increasing. H.R. 1134 would help those school districts which have not yet begun to use computers by providing them with information on available software and courseware.

When the Superintendent of Schools in Houston recently addressed the First Educational Assembly of the National School Boards Association he related the experience of Houston. The Houston schools have made a strong commitment to computers and plan to use computers and videodiscs for fifty percent of the school's instructional needs within five years. The Superintendent's advice to the assembled superintendents was "Have a plan. Make sure you have an expert or hire one." If we establish the National Centers for Personal Computers in Education we will relieve some of the pressure on smaller school districts, and poorer school districts, to hire their own experts. The National Centers will be able to assist them in developing their own plans. I think that this is an important and attainable goal.

Let me briefly recapitulate what H.R. 1134 does. It establishes the National Centers for Personal Computers in Education under a grant program of the National Science Foundation. The number of Centers will depend on the available funds. The purposes of the Centers would be to identify existing educational computer programs and develop new educational courseware; to develop teacher training materials; and to monitor and disseminate new materials in educational technology. I would like to highlight one particular function of the Centers; the Centers will set up a mechanism to inform the computer industry of the specific computer needs of education. We must keep in mind that the development of new computer technology is a two way street. If industry is able to ascertain the particular problems and needs of educators, it will be better able to respond to those needs. The grant shall last for three years, at the end of which time each center will have to evaluate the program and publish a report on its implementation.

Mr Chairman, establishment of the National Centers for Personal Computers in Education would be a first step in dealing with the much larger issue of computers' effect on education. We must make a strong commitment to support the best use of computers in our schoolrooms that is possible. That is why I also sponsored the Computer Literacy Act of 1983, H.R. 3750, which was introduced by my distinguished friend from Colorado, Congressman Tim Wirth. I strongly support Mr. Wirth's bill and am encouraged that it deals with many broader computer issues.

I think that it would be entirely appropriate if the specifications contained in H.R. 1134 concerning the National Centers for Personal Computers in Education were to be incorporated into Title III of H.R. 3750. This would provide a comprehensive approach to the problem of the development and dissemination of computer information and it would also allow a closer interaction with the activities of the National Institute of Education which has already begun to develop some of the means necessary to disseminate such information. I believe that the Nation's schools will benefit greatly from such a strong and comprehensive approach.

Finally, I would like to commend the Members of this Subcommittee for their continuing attention to the needs of educators and students. I am sure that together we can fashion a bill that will bring the fruits of computer technology to all schools and students in the United States.

STATEMENT OF HON. THOMAS J. DOWNEY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. **Downey**. Mr. Chairman, unless somebody tells you something different, I can stay 'til 10 o'clock at which time the Ways and Means Committee goes into session.

Chairman **Perkins**. Go right ahead and then we will interrogate.

Mr. **Downey**. Thank you, Mr. Chairman. A year ago I appeared before this subcommittee to present a statement in support of H.R. 1134, a bill which I introduced to create National Centers for Personal Computers in Education and I appreciate the subcommittee's continuing attention to this bill. I welcome the opportunity to speak briefly about it this morning.

I believe the need for this bill has increased since it was first introduced in 1978. Although no one doubts the importance of computers in education today, there is little concrete assistance given to school districts, administrators and teachers in overcoming the many problems they encounter in integrating computers into the schools of the Nation.

A recent study by the Center for Social Organization of Schools at the Johns Hopkins University found that though the use of microcomputers was growing in schools, most new microcomputers are being purchased by schools that already use computers. It would seem that the greatest difficulty lies in the initial introduction of computers into schools. Once that bridge is crossed then further development of computer use is relatively easier.

It would also appear that the gap between more affluent schools that already have committed themselves to computers and poorer schools that may not have had the resources or the expertise to use computers is growing. H.R. 1134 would help those school districts which have not begun to use computers by providing them with information on available software and courseware.

When the superintendent of schools in Houston recently addressed the first educational assembly of the National School Boards Association he related the experience of Houston. The Houston schools have made a strong commitment to computers and plan to use computers and video disks for 50 percent of the schools' instructional needs within 5 years. It was the superintendent's advice to the assembled superintendents to "Have a plan. Make sure you have an expert or hire one." If we establish the National Centers for Personal Computers in Education, pressure on smaller school districts and poorer school districts to hire their own experts will be decreased.

The National Centers will be able to assist them in developing their own plans. I think that this is an important and attainable goal.

Let me briefly recapitulate what H.R. 1134 does. It establishes National Centers for Personal Computers in Education under a grant program of the National Science Foundation. The number of centers will depend on available funds. The purpose of the centers would be to identify existing educational computer programs and develop new educational courseware, to develop teacher training materials and to monitor and disseminate new materials in educational technology.

I would like to highlight one particular function of the centers. The centers will set up a mechanism to inform the computer industry of the specific computer needs of education. We must keep in mind that the development of new computer technology is a two-way street. If the industry is able to ascertain the particular problems and needs of educators, it will be better able to respond to these needs.

The grant shall last for 3 years at the end of which each center will have to evaluate their own program and publish a report on its implementation.

Mr. Chairman, establishment of the National Centers for Personal Computers in Education would be a first step in dealing with the much larger issue of computers' effect on education. We must make a strong commitment to support the best use of computers in our school rooms that is possible. That is why I have also cosponsored the Computer Literacy Act of 1983, H.R. 3750, which was introduced by my distinguished friend from Colorado, Congressman Wirth. I strongly support Mr. Wirth's bill and encourage that it deals with many broader computer issues.

I think that it would be entirely appropriate if the specifications contained in my bill concerning the National Centers for Personal Computers in Education were incorporated into title III of H.R. 3750. This would provide a comprehensive approach to the problems of the development and the dissemination of computer information and would also allow closer interaction with the activities of the National Institute of Education, which has already begun to develop some of the means necessary to disseminate such information.

I believe that the Nation's schools would benefit greatly from such a strong and comprehensive approach.

Finally, I would like to commend the members of the subcommittee for their continuing attention to the needs of educators and students and I am sure that together we can fashion a bill that will bring the fruits of computer technology to all schools and all students in the United States.

Thank you, Mr. Chairman.

Chairman Perkins. Let me ask Senator Gore here this morning, do you want to keep your bill separate and not merge it with the other bills here? Do you have some feeling along that line?

Mr. Gore. Well, first, Mr. Chairman, let me thank you for promoting me the easy way. I am working on it the hard way.

I would be content with the judgment of the subcommittee on that measure. I think that there are differences between this legislation and the others that are being considered. This one has a more narrow focus in that it is directed just at the educational software problem. I think the answer to your question would depend in part on your expert judgment as to legislative strategy. If you think its chances are increased by merger, then, of course, I am all for that. Otherwise, I prefer to keep it separate. But I will accept the subcommittee's judgment.

Chairman Perkins. Senator Lautenberg, I don't see much difference in your approach and Mr. Wirth's approach except that your bill seems to favor the poorer districts of the country perhaps to a greater degree. Am I correct in that analysis?

Senator Lautenberg. Mr. Chairman, in part because we are saying that 50 percent has to be directed toward the poorer school districts. But I think there is another difference though, again, many of our objectives are similar and would eventually, I think, be merged, and that is that our focus is on the planning side. What we are saying to the school districts is, "Think out very carefully how you intend to use this. We don't believe that hardware alone is the answer and, frankly, we don't believe that software alone is the answer. The curriculum has to include all of these parts of the tripod and that is the teacher trainers who are equipped to do the training, the software and the hardware." So we are talking about the planning process as the critical element in this. I want the schools to tell us how they intend to use it, not to just throw hardware out there. If you give a nontrained person an airplane, it could be the best functioning airplane in the world and it's not going to do them any good. The same thing is true, very frankly, of computers.

Chairman Perkins. Now, Mr. Downey, do you believe that your bill could be blended in with Mr. Wirth's bill?

Mr. Downey. Mr. Chairman, I do. I think it could find a happy resting place in title III of Mr. Wirth's bill. The goals, as distinguished from Congressman Gore's bill, are much more similar to what Mr. Wirth is trying to do. So, I think that we are little more specific with respect to the use of courseware and software and the need for centers than Mr. Wirth's title III, so I think we could find real accommodation there.

Chairman Perkins. Mr. Miller, you have been sitting here the whole time.

Mr. Miller. Thank you, Mr. Chairman. I want to thank the members of this panel for their work. Last year there were a lot of speeches about computers and technology and the need to do certain things about it. I am delighted that all of you have stuck with this subject. I think you have presented what I hope will become a package for this committee to report out because I think that the concerns that you address and that others will address later this morning must be addressed and that is there appears to be a basic mismatch between the educational institutions in this country and the availability and the utilization of this technology for learning purposes. After watching all of the commotion last year, it does appear that computers are something that you are simply going to lay on school districts and they are going to use to their highest and best use.

We would do well, I think, to take a little additional time to find out how the school districts are prepared to use this, whether they are prepared to use them, whether there will be safeguards for the investment that we are prepared to make. Also, I think, Albert, that your legislation to encourage, to the extent that we can, if it's feasible, the private sector in the educational field.

Early on, when we had hearings out in California, it appeared that some of the educational programs might have been there to dazzle Members of Congress more than they were to educate the students. I am concerned now a couple of years later that we might not have come as far as we could possibly come. Perhaps by at least providing some prospect of a market for people who want to upgrade the software, we might be able to do that.

I would just finish by saying that, Mr. Chairman, I would hope that we would also understand finally that the utilization of computers is not going to be properly done absent the willingness of the instructors in our school systems to accept them and to use them. I think that whether we have the national center, whether we provide training programs, as Senator Lautenberg does, we must address that issue because we talk about computers being user compatible or friendly. If they are not friendly or compatible to the instructors in the classroom, they will sit idle as later witnesses will show us, that they are used very few hours of the school week or the school day.

So, I would hope that the committee would have the desire to incorporate the best aspects of these three or four different pieces of legislation and really put forth a thoughtful proposal that can be utilized and not simply our desire to look like we are participating in this technological revolution with respect to education. I know that we have some plans to mark up several pieces of this legislation. I would hope that we would find a way in which we could incorporate them into, finally, a package that addresses the educational needs and desires for computer literacy.

Thank you.

Chairman PERKINS. Mr. Bartlett.

Mr. BARTLETT. Thank you, Mr. Chairman. I appreciate the testimony and the bills. I have essentially one open-ended question for all of the witnesses. As I read your bills, I contrast them, for example, with the bill that passed this House last year, H.R. 1310, which is the Math and Science Improvement Act, which, in fact, provided more or less block grants for math and science around the country. But then it permitted use of those funds, in part if they so choose, for computers and their applications and for hardware and software acquisition. I would detect that the thread that seems to be running through your bills that's different from what was in that bill would be that you would encourage a nationally directed acquisition of computer hardware, as well as development of curricula and software development. Some of us on the committee—it was reflected in part in H.R. 1310—would tend to assist school districts with some extra funds, but would leave to the local school districts discretion on how to apply and how to develop the curricula. Is that generally the difference?

Senator LAUTENBERG. If I might, Mr. Bartlett, that is not the intent of our bill. It is intended to encourage the development by the local school districts of the curriculum and the program necessary to use the technology for general teaching. We create a training facility or a training program just to make sure that there are teachers, there are instructors, available to handle the course work and we make the demand, again, of the school district for a plan or a program for implementation.

So, our mission is to make sure that the local school district is very involved, that they have—a critical element for us is to train people to work with these tools and to make sure that they know what they are doing when they get into the classroom to work with the students. We prefer the local initiative wherever we can get it.

Mr. DOWNEY. I wouldn't change that at all other than to say that my legislation doesn't contemplate that there is a national answer to a lot of different problems. So, I think that you will find that different school districts obviously need different things. With the national centers, I contemplate that they would be regional in nature so that they would be adapted to a region's needs and that school districts can draw on the expertise available there for their own purposes, that this would not be saying, "Yes, here is the ideal way to learn math or science or to understand English," but that there are a variety of ways to do that and those variety of ways would be available at a regional center near the locality.

Mr. BARTLETT. If there were ways to perhaps introduce some flexibility into your bill, that would not be outside of your intentions? Let me give you an example. On the top of page three of Mr. Downey's bill, you describe the responsibilities of the center, and one of the responsibilities would be "to identify and develop curriculum materials for instructing students." So, you contend that that would not be national curriculum, but regional curriculum, which is still not school district curriculum?

Mr. DOWNEY. Absolutely.

Mr. GORE. If I could respond to your first general question. This legislation, H.R. 4628, is not designed to have a national directed effort. It is designed to bring to bear the resources of small businesses, entrepreneurs, high tech startup companies and venture capitalists to bear on the solution for this problem.

I think that, if I can give a broader philosophical answer to the question I think you are getting at, eventually, over time the forces of the market would work this problem out, but it would probably take a very long time because of the nature of this market. When you have school districts, principals, and teachers all across the country with almost 100 different formats in the hardware they are using, all scrambling for a few good educational programs, venture capitalists are not interested in participating in that kind of market. They are just not doing it. They are going to other parts of the computer market. The talented software writers are not spending their time and effort going after the educational market because there are much more lucrative opportunities and the marketplace looks very chaotic to them.

I stress that eventually, over time, it would undoubtedly sort itself out, but if we can hasten the time when we take full advantage of this technology in improving education, the returns for our country are going to be remarkable.

What this bill does by contrast to the earlier effort passed last year is to try to draw the entrepreneurs and the ventures capitalists toward a more concentrated focus on educational software.

Mr. **Bartlett**. Thank you, Mr. Chairman.

Mr. **Miller**. Mr. Chairman, if I might.

Chairman **Perkins**. Go ahead, Mr. Miller.

Mr. **Miller**. Just in that vein, as we put forth under Senator Lautenberg's bill a substantial amount of money for the purchase of hardware, what is the intermediary between the school district that goes out to purchase hardware that has a plan to use that and recognizing whether or not that's going to be compatible, assuming that we could develop educational software as you would like to do. I don't know if that's Mr. Downey's national centers because I think there are already school districts that have made purchases of hardware that now find out that it cannot be utilized. There is a proprietary interest in developing software for only certain kinds of hardware.

How do we address that? You have millions of schoolrooms, if you will, and many unsophisticated purchasers and I guess I am just terribly concerned that we end up with a lot of hardware. We went through this years ago with education aid and we ended up with a lot of tape recorders and slide projectors stashed away in the closet because they were never quite used or there was no follow-on program.

I like the package that is here but I am very concerned that it become integrated so that the Federal Government doesn't lay out $150 million to buy obsolete equipment or equipment for which there is no follow-on program.

Senator **Lautenberg**. Mr. Miller, the observation is a proper one. You said something in your earlier remarks that I had to reflect on for just a moment. The programs that you saw operating out there you thought maybe were developed to dazzle the Congressmen. Since I come from the computer corporate world, I am more dazzled by the process of the Congress than I am by the programs that we would be looking at.

It's our intention that this not be $150 million worth of hardware purchase. As a matter of fact, we specifically in our bill encourage the planning process to take place by allowing some part of those funds to be used specifically for planning, to encourage the districts to go ahead and call on consultants. We would like to see it done through the State departments of education. That's where we think the assignment ought to come and for the priorities to be established by those groups.

I offer our bill, $150 million, not an enormous sum of money by any yardstick, for 4 years to try and model something for the future. Four years is a short period of time and, again, not a terribly large sum of money, to see what happens when the school districts have an opportunity to work with the hardware of their choice.

Now, there certainly has to be a recommendation to say, "Listen. Don't take this piece of hardware that was developed last week by three young people—and I won't say California, but New Jersey or someplace else—and they may not have the capital or the resource to continue their business. Some kind of guideline has to be there.

But I think the guideline is going to be essentially, "What kind of programs, what kind of teaching instrument is this going to be," and I believe that the process of review and on-line work that we will find out where we ought to be apportioning the money between hardware, software and, again, teacher training.

Mr. **Miller.** My concern is there is a lot of little school districts, as Tom points out in his testimony, that will not have the expertise. If you even read the literature around the personal computer, a lot of things that are said to be IMB—or Apple-compatible don't turn out to be so compatible. They don't quite work that way. They need modifications. My concern is how do we get the match between the software that Congressman Gore has addressed himself to that I think is essential and the fundamental need of a school district to have the resources with which to purchase the hardware so that we don't have people who end up with something that is not manageable or cannot be utilized to its highest potential.

There are horror stories in this industry about people who have made investments—major corporations that have made investments in information systems only to find out that it never met their needs and are pulling them and putting in new ones. It's an evolving industry and I am afraid that we look at it sort of in the static approach that, "If you could just get yourself this hardware, this software and a student, you could work it out and have better educated product." I don't know if this technology allows for that.

Mr. **Gore.** If I could address that just briefly. This chaos and incompatibility in the market is part of the reason why venture capitalists, entrepreneurs, software writers are now staying away from the educational market. Part of the incompatibility problem on which your question is premised has to do with the design of the software. If you take the five leading formats that are currently in use in schools today, you can design a piece of software in a fashion that makes it relatively easy to translate that software from its original format into the formats compatible with the other four leading systems.

Unfortunately, today it's commonplace when a good program is developed for the architecture of that program to be designed in a way that locks it into one specific format and makes it very difficult to translate it into the others. To the extent that the criteria used by this board established in the software corporation would include ease of translation and compatibility, you would stimulate a flow of high quality educational software that was not format-specific, but could be replicated into the different formats that are in use.

So, in part, this provides an answer to that problem. One final comment on this. The subcommittee ought to have—in my view, I think it's critical to have a clear view of exactly what the nature of the currently available software is. Some programs dazzle——

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Mr. MILLER. Let me ask you—I am going to get very fundamental here.

Mr. GORE. All right. Go ahead.

Mr. MILLER. If we passed a Federal law that said, "Schools will be only allowed to buy an IBM Personal Computer," would the market in software develop itself because the potential to play on that record player, as you pointed out earlier, is simply so great now that people are going to respond to that. My concern is that we have people buying $39 computers and $3,900 computers——

Mr. GORE. Well, that's precisely what's happening in the business market today. It's all flowing toward IBM-compatibility.

Mr. MILLER. I understand that.

Mr. GORE. Down the scale that is not happening. There is still a much greater diversity.

Mr. DOWNEY. George, if I can try and deal with your question because I think I have an answer for it. It is something that I have seen in school districts on Long Island. The threshold decision as to what computer to buy for the school district should be answered by someone who has no axe to grind, no product to sell. That is the whole purpose of the national center or the regional centers because you would be able to go there and make the threshold decision with impartial experts who would say look, "You have got a school district where your children are falling behind in reading, or you have these other problems, we suggest that this is the system and this is the type of course that you might want to look at," as opposed to what the superintendent of the Houston schools told the educators, "Look. Have an expert." A lot of schools are never going to be able to afford experts. Frankly they are not going to have the money to be able to make mistakes. That is the purpose of our bill—to make sure that school districts, in that sense, are guided to the right type of equipment and to the right type of coursework.

Chairman PERKINS. Congressman Wirth, we are delighted to welcome you here this morning. We have had, I think, a very healthy discussion. I mentioned to Congressman Downey about the blending of his bill and your bill together and to Senator Lautenberg that perhaps his bill would serve some more needier sections of the country than your bill, but we are delighted to hear from you at this time. We want to take some action, when we get these hearings completed on these bills.

Mr. Gore has stated that he has no objection if his bill can be blended in and we may just do that. I had previously understood that Mr. Gore thought maybe his bill should be reported separately. We will try to carry out your wishes along that line, Mr. Gore, if you still think it should be reported separately and we will have to report two bills.

Senator LAUTENBERG. Mr. Chairman, is it possible for me to be excused? We have a markup.

Chairman PERKINS. Yes, thank you very much, Senator Lautenberg. We appreciate your coming here this morning. You have been very helpful to us.

Senator LAUTENBERG. Thank you very much.

Chairman PERKINS. You take his seat, Mr. Wirth.

STATEMENT OF HON. TIMOTHY E. WIRTH, A REPRESENTATIVE IN CONGRESS, FROM THE STATE OF COLORADO

Mr. WIRTH. Mr. Chairman, my apologies for not being here. The reason that we are hear with this legislation is a question of educated computer literate haves and computer literate have-nots in this society. I just came from a session related to the Federal Communications Commission's recent order in which we are going to have, if we are not careful, telephone haves and telephone have-nots and that's why I was late and delayed and my apologies. The issue is very much the same. You all have talked about that and we appreciate your continuing concern to make sure that all children in this country have access to this future. The question that we face, obviously, is how do we do this?

One issue is the hardware and I think Senator Lautenberg has addressed that and how do we get hardware into poorer schools and how much is that going to cost? That is probably an issue of levels of money and not a question of process.

The other two issues are more difficult, I think—teacher training and the question of broad expertise. The teacher training issue, I understand, has not been extensively discussed this morning. As the chairman remembers, we went through a great deal of time in the 1960's in the United States focused on teacher training and teacher retraining. That is one of the things that we know how to do and we know how to do it very effectively.

Now, the bill that I have offered, combined with Congressman Downey's bill, provides that kind of a base in expertise and approach—building on what we already do to retrain teachers. Realistically, we are not going to go out and recruit a lot of new computer, math, and science teachers in this country. We are going to have to retrain what we have. Let's get on with that business. We can do it relatively inexpensively and with great effect.

The third part of the equation which you were talking about when I came in, the questions of the software and the compatibility issues, are always difficult. Mr. Downey and I, I think, have come to an agreement on how to put the two approaches that we have talked about together providing basically a clearinghouse and information.

A different approach is that suggested by Congressman Gore, setting up a somewhat private corporation, as I understand it, to perhaps help direct the marketplace more aggressively than Mr. Downey and I would suggest ought to be done, but these are, I think, separable issues, as you were suggesting.

I have a more complete statement, which I would hope would be included in full in the record, if I might, and I will stop here. I appreciate very much your having this hearing and your continuing concern, Mr. Chairman.

To summarize, we have three basic issues: Have and have-nots—we want to make sure that there is not that kind of division; No. 2, retraining of teachers; No. 3, compatibility. I think all of those issues are addressed if we could knit these three pieces of legislation together.

[Prepared statement of Timothy E. Wirth follows:]

PREPARED STATEMENT OF HON. TIMOTHY E. WIRTH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF COLORADO

Mr. Chairman, I would like to first express my appreciation to you and the members of the Subcommittee for holding this hearing to discuss a very important issue facing our nation's schools: computer literacy. I would also like to thank your staff for the help and advice they have given us.

Our nation is undergoing a transformation unlike any we have witnessed since the industrial revolution—the information revolution—and the speed with which this is occurring is startling. The number of computer-related jobs will rise to 30 million by 1990. Basic computer skills are becoming a prerequisite for a large number of new jobs in our economy as the computer becomes an office machine almost as common as the typewriter. Yet, according to a recent study, there are only 325,000 microcomputers in use for instruction of America's 40 million students.

Just as alarming is the disparity that is becoming increasingly evident when one looks at which students have the opportunity to benefit from the information revolution. In schools in high income areas, it has been estimated that there is roughly one computer per 100 students. However, in the nation's poorer school districts, this ratio increases dramatically to approximately 200 students per computer. While these ratios have improved in recent years, poorer schools continue to lag behind, threatening the development of a class of technically illiterate Americans who will be effectively shut out of competition for jobs in a rapidly changing economy.

The problem of computer literacy is much broader, however, than simply furnishing schools with computers. As we learned in the 1960's there is potential for great waste by merely placing new equipment in schools without adequately training teachers how to use the equipment. Particulary in these times of fiscal restraint, such waste must be avoided. In addition, a concern voiced by virtually every education official who has addressed the issue of computer literacy is the lack of quality software and the difficulty of obtaining information on what computer hardware and software would best meet an individual school's needs. The problem of computer literacy must be dealt with through a three-pronged approach addressing each of these areas.

These problems were highlighted in a report entitled Educating Americans for the 21st Century, recently by the National Science Foundation's National Science Board. While the use of modern information technology offers tremendous potential for improving education, the report said, there are certain problems which must be dealt with, such as the income gap between those who do and do not have access to computers, the need for training teachers to use these new technologies, and the gap between what is being produced and what teachers actually need to teach our children.

In addition to these two serious problems which must be addressed, I would like to point out that there is a third justification for this legislation. Research on computer-assisted instruction indicates that computers can be an effective learning device. I would like to submit for the record results of research concluding that computer-aided instruction can raise the academic performance of elementary students by as much as sixteen percent and of high school students by as much as thirteen percent. While more research is needed before firm conclusions can be drawn, these results are an indication of the positive impact computers can have on the education of our nation's student.

The Computer Literacy Act represents a comprehensive approach to each of these problems. The bill has four purposes. Title I would provide schools with the funds to purchase computer hardware. This money would be spread evenly throughout our nation's schools so that every student will have equal access to the equipment, with priority going to schools with the greatest need. A direct grant approach, rather than providing tax incentives to corporations who choose to donate computer to schools, was chosen as the most efficient and effective means to achieve these educational objectives. Specifically, the tax code approach provides no assurances schools in poorer districts would have the same access to such equipment as would schools in wealthier districts, and there is no guarantee that schools would obtain equipment best suited for their educational needs. Furthermore, a tax code approach does not address the remaining issues of teacher training and information sharing.

Title II would establish teacher training institutes to instruct teachers in the use of computers. These institutes are modeled after those created by the National Defense Edcuation Act (NDEA), which the Congress passed in response to the Russians' launch of Sputnik in the late 1950's. Like the program established under the NDEA, teachers who attend these institutes would receive a stipend as a substitute for income is lost as a result of attending the institute.

Title III would encourage the development of model courseware, as well as call upon the National Institute of Education (NIE) and the National Science Foundation (NSF) to provide grants or contracts to evaluate existing hardware and software and to disseminate this information to our nation's schools. As you know, Mr. Chairman, there are several bills pending in the House on the issue of information sharing and software development. While all of these bills have the same goal in mind, significally different means have been proposed to achieve these objectives. After studying the issue, I concluded that NIE is partically well-suited to fulfill the information-sharing function. The Institute currently has in place an extensive mechanism through which it communicates to schools across the country. By plugging into their existing network, information on computer technology can be transmitted to schools in a very effective manner without creating any new program or mechanism. The NSF is well-suited to evaluation of existing hardware and software given its highly qualified staff, as well as the experience they have in this area. However, there were aspects of legislation introduced by my colleague, Rep. Downey, which improve on the provisions of H.R. 3750. In particular, Rep. Downey's legislation, H.R. 1134, outlined in more effective and specific detail the objectives of any effort to improve the sharing of information. For these reasons, Mr. Downey and I have agreed to an approach which we would be happy to recommend to the Committee which we feel will combine the best of both bills. We have worked with Chairman Perkins and his staff on this issue, and would be happy to discuss this further with other Committee members who may be interested. I would like to thank Mr. Downey and his staff for their help in this effort.

Finally, the bill would establish model adult training programs in which computers, when not being used by students in the afternoons after school is out, can be used to teach adults and prepare today's workers for an economy that will soon be upon us.

This legislation has broad support, having been cosponsored by 80 members of the House and endorsed by the National Education Association, the National PTA, the American Association of School Administrators and the Rural Education Association.

In closing, I would like to again thank the subcommittee for their attention to this issue and for holding this hearing, and I would be happy to entertain, questions any member may have.

Chairman PERKINS. Let me ask you, Tim, what's your best judgment about the type of bill that we can enact this year?

Mr. WIRTH. On the one hand, if you were to take Mr. Downey's bill and my bill and put it together, over a 10-year period of time we are talking about a not insignificant expenditure of money. On the other, we are talking about a cost over the next 10 years that is one-seventh the cost of last pattern, a carrier battle group, in the water.

Chairman PERKINS. While you are on the cost factor, do you think we should enact a more or less modest bill to get it through the House Chamber?

Mr. WIRTH. Well, I would hope that we could go to the House floor, Mr. Chairman, with the idea of what, in the ideal world, we ought to do and then point out that we live with reality. But I think it is our responsibility, and it is also my own belief, that you make the case that you think is the right case to be made and you carry it as far as you possibly can. When we get to the House floor, I think the bill will inevitably get pared down, but it is our responsibility to say, "This is what we believe is the right formulation." We do that going up to the House floor and when we get onto the House floor, make the changes that I think you and I realistically understand have to be made.

That's the toughest issue. Beyond that, it seems to me, the component of information, as Mr. Downey has been suggesting, the notion of teacher training and the notion of how you get the hardware into the schools, as Mr. Lautenberg and Mr. Downey and I have all suggested, are very easy to put together in a single bill.

Chairman **Perkins**. Well, assuming that the Committee approves the substantial local grant program, do you feel that it would float on the floor, or should we cut it down considerably and perhaps blend your bill together with Mr. Downey's bill? Just give me your views along that line right now.

Mr. **Wirth**. I think Mr. Downey's bill and my bill are mergeable but they don't really focus on the cost issue as much as the compatibility issue. Mr. Downey and I have come to agreement, working with your staff, as to how the two bills go together. That leaves aside, however the question of cost. I suspect we are going to get on the House floor and say that we better do it perhaps more modestly than I think any of us in this room would like to see us do in the ideal world, but we don't live in that ideal world. So maybe we will have to phase in the grants to local school districts in some fashion.

Chairman **Perkins**. Back in 1965 when we enacted the Elementary and Secondary Education Act—of course, we did not have all of the computer technology then that we have today—there was a great hue and cry throughout the Nation about inadequate equipment, outmoded equipment. At that time, we didn't allow school districts to carry over funds. Over $1 billion was spent for equipment in the early years. Then dozens of witnesses came in here later told us about how little that equipment was utilized. In other words, we just threw so much money away back in those days. So, we have got to guard against throwing money down ratholes.

These bills are all deserving bills and we have got to take action in this area. We just want to take the best action, that's my judgment.

Mr. **Wirth**. I think you are absolutely right. Mr Chairman, you will remember that I had the privilege of running the title I program in the late 1960's and we were very aware of that point, of warehouses, storerooms filled with audiovisual equipment and so on that was bought with title I money because school districts didn't know what to do, which is precisely why Congressman Downey and I address the compatibility issue, the question what's good, what isn't good, and how do you use it, and the teacher training part of it. Those were bitter lessons, I think, that we learned from the 1960's—how do you use this equipment and how do you train teachers and develop curricula around it? That may argue for as you point out, more of a walk-before-we-run operation in terms of moving computers into the classrooms. On the other hand, we have had a lot of experience in an awful lot of communities in the country where very, very effective computer education courses have been set up.

My own backyard, Adams County, CO, is, I think, the first school district in the country where computer literacy is a requirement for graduation. We have a lot of models like that around the country that can be used.

Chairman **Perkins**. I was a classroom teacher myself back in 1933, right in the heart of the Depression, for $59.60 a month. I decided that nobody could make a living at that wage and I got away from it. I taught in the Knott County School System. But I am very conscious of the way that the present Congress is constituted and the difficulty we will have on the floor if we leave in any loopholes. We have had all of that experience with seeing a lot of money wasted in our lifetimes and that problem concerns me to a great degree and we want to scrutinize it and make sure that we get something that will float on the floor. That's what I am interested in. Go ahead, Al.

Mr. **Gore**. Mr. Chairman, yes. I wanted to clarify one point. In my earlier response to your question about the possibility of merging H.R. 4628 with the other bills being considered by the subcommittee. I expressed the preference to keep it separate but I expressed some deference to your judgment and advice. Perhaps I could take the opportunity to pursue that advice after this forum is completed later today, but my preference is to keep it separate.

Chairman **Perkins**. Go ahead, Mr. Downey.

Mr. **Downey**. I have nothing to add to the eloquence of my colleagues' previous statements, Mr. Chairman.

Mr. **Miller**. Mr. Chairman.

Chairman **Perkins**. Go ahead, Mr. Miller.

Mr. **Miller**. Tim, if I could ask you, does your legislation require any local match? Senator Lautenberg's bill does—it's a 75-25 proposition. My understanding is you don't.

Mr. **Wirth**. I don't believe we do.

Mr. **Miller**. One of the things that we have tried to do in this committee in this general area is to try to encourage the participation at the local level, in some instances of local industries, and other organizations, to provide a public/private match because, in some cases—I know in a number of districts in California—some of the computers, in fact, have been provided by industries as part of a training program and we want to recognize that. If the district can go out and get that kind of participation by the private sector, we would be willing to recognize that and also the issue of whether or not there ought to be some burden on the local districts in terms of participation in this effort.

Mr. **Wirth**. In the ideal world I think the gentleman is absolutely correct. However, as you know, one of the problems of poverty is that people are poor and they don't have money, however. One of the problems that we have got in some school districts is a vicious cycle where there aren't businesses in those school districts that can help fund it, and there aren't local matching moneys that can help a very poor district to provide its own equipment. The capacity for that match isn't there versus other districts where there is a great deal of money.

Mr. **Miller**. Well, we have boilerplate language for those districts in this committee. [Laughter.]

Mr. **Wirth**. That's exactly the kind of problem that I am concerned about, that if you don't start with the assumption that there are a great number of districts in the country that simply can't afford to do it, those kids are going to get behind the eight ball before they even start. If you don't start from that assumption, they may well get left out and that's why we do it that way.

Mr. **Miller**. I understand that, but by the same token, there is a recognized disparity in terms of districts that have these resources and don't and, historically, when we have gotten involved in education, it's to try to provide some tilt toward the have-nots so that the same opportunity is available. I think that's our concern—to what extent we can save some resources. Those who can afford to help us, do so and for those who can't, that's been historically the role of the Federal Government.

Mr. Wirth. I couldn't agree with you more. Let's just make sure that we build some of that tilt in so that those districts that can't afford it get help, and those districts that can, are the ones that are encouraged to participate.

Chairman Perkins. We have had some Republicans here, too, this morning, but we don't have any at the present time. Mr. Bartlett was here and took part in our interrogation.

Mr. Wirth. We would have Republican school districts participate in this as well, Mr. Chairman, I'm sure. [Laughter.]

Chairman Perkins. Let me thank all of you distinguished gentlemen this morning. You have been very helpful to us and we intend to take some action in this area.

Mr. Wirth. Thank you very much, Mr. Chairman.

Chairman Perkins. All right. We have got some other witnesses here today on the same subject, a panel. We have got Mr. Marc Tucker, Director of Project on Information Technology and Education, Washington, DC; Ms. Judy Anderson, teacher, East Consolidated School District, St. Paul, MN, accompanied by Robert Pope; and Ms. Dorothy K. Deringer, vice president for Atari Learning Systems, Sunnyvale, CA.

All right. Our first witness is Mr. Tucker. Go right ahead.

[Prepared statement of Marc Tucker follows:]

PREPARED STATEMENT OF MARC S. TUCKER, DIRECTOR, PROJECT ON INFORMATION TECHNOLOGY AND EDUCATION

Thank you Mr. Chairman. I am Marc S. Tucker, Director of the Project on Information Technology and Education. The Project is funded by the Carnegie Corporation of New York, a private foundation. For the last two years I have been examining the use of computers in our nation's schools and working with local, state and federal policy makers to help them make sure that computers are used to the greatest possible advantage for our students. I very much appreciate the opportunity to present my views on the bills being considered by this committee.

What the Congress does this year about computers in our schools will make a big difference. The bills you are considering represent very different conceptions of how computers should be used for education, Much of the language contained in HR 1134 and HR 4628 assumes that computers should be used as teaching machines and defines the problem in terms of creating high quality software and training teachers to use it. That represents, in my judgment, a profound misunderstanding of the potential of computers to improve education. Software is not the problem, but if the Congress proceeds as if it is, it would make it virtually certain that computers will contribute little, if anything, to the education of our students.

One bill, HR 3750, has a good deal of promise, because it recognizes the potential of the computer as a powerful tool in the hands of students and therefore defines the problem mainly in terms of student access to computing capacity. Whether or not computers live up to their billing in the schools is more than anything else a function of how many computers the schools have and how they choose to use them.

We are, in the schools, treating computers like books. As if they could not be used without learning their language, as if they were texts to be viewed or read. But computers are much more like pencils than books. They are tools, just as pencils are tools, but far more powerful extensions of the mind. What we are doing in the schools is like giving courses in pencil—the history of pencil, structure of pencil, social implications of pencil, ethics of pencil. We know that pencils are tools, so we make sure that our students have pencils. We do not give them pencils for twenty minutes a week. Computers are vastly more powerful and versatile tools than pencils, and, as the future unfolds, people who are not versed in the use of computers will be far more disadvantaged than those unversed in the use of pencils.

Before exploring the implications of using computers as tools in the classroom, however, it might be useful to share some information about the current state of computing in our schools. First the numbers. At the beginning of the current school year there were about 325,000 computers and terminals being used in the schools for instructional purposes, up from a little over 50,000 two years earlier. More high schools have computers than junior highs, more junior highs than elementary schools. Only 14% of our school districts are without computers; 68% of our schools have at least one. Last year, among high schools, twice as many of those serving the well to do had computers than those serving low income children; since then, the gap has narrowed, but there is a long way to go to make up the difference.

But growth rates can be misleading. Our schools are not stuffed with computers. On average, our high schools have 11 computers each, junior highs 7 and elementary schools 3.5. 325,000 machines do not go far when there are 45,000,000 school children in this country. But even these numbers are misleading, because not all of the available machines are in use, and those that are are not in use throughout the school day.

A study by Henry Jay Becker of Johns Hopkins University tells the story. In the typical elementary school, the computers are in use only 11 hours a week, at the secondary level only 13 hours a week. In one-quarter of our elementary schools and one-fifth of our secondary schools, the equipment is used only an hour a day. Not all students who use computers get to use them every week, but, in our average computer-using elementary school, those students who get to use computers in any given week get to use them for less than thirty minutes. In our high schools, fewer students in the school usually get to use computers at all, but those students get a little more time on the machines.

Even more important is the question of how these computers are used. 80% of students' time on computers is devoted to two uses, 57% for computer literacy, which mostly means learning computer programming, and 23% for computer-assisted-instruction, which mostly means drill and practice, much of it in arithmetic.

In my opinion, these applications are generally a waste of time. Only a handful of people make their living writing computer code in this country. While there is currently a shortage of professional programmers, most experts believe that, by the time most of our current students leave school, we will need many fewer programmers than we now have. It makes no sense to train millions of students to program if we are doing it because we think they will have to program computers in order to use them. The vast majority of people who use computers in the workforce, including many who use them in very sophisticated ways, never write computer programs, but instead use packaged programs written by others. Though it is doubtless useful to know how to program in order to modify packaged programs when necessary, it is very much more important in the workplace to know how to use packaged programs.

The teaching of programming in the schools is a relatively recent phenomenon. But computers have been used to deliver instruction for many years. In the last few years, delivery has shifted mainly to microcomputers. For the most part, however, what the student sees on the screen is the old paper and pencil workbook, with the computer turning the pages. Though students who get their drill and practice on the computer do better than students in conventional classrooms, another method—older students tutoring younger students—is both a more effective and less expensive way to improve the basic skills of low-achieving students. Computers are being used for this function not because they do the job better than anything else, but because using them is trendy.

Not all computer-assisted-instruction is drill and practice in arithmetic, spelling and naming state capitals. There are programs available to teach physics, chemistry, economics, more advanced topics in mathematics and a wide range of other topics. Educators complain about the quality of these programs and have sought government support to develop betters ones.

But there is no reason to believe that the current generation of computers will ever be very good at delivering instruction, like a computerized text. Lack of funds for software development is not the problem. Computers are good trainers but poor educators. Using them to deliver serious instruction is to misunderstand what a computer is and how it can best be used.

Now, it turns out that if you think of the computer as a tool in the hands of the student, rather than as a device for delivering instruction, then computers can be very powerful aids to the learning process. In this context, we can see that we already have most of the software we need.

Take writing, for example. Most students, from kindergarten through high school, rarely are asked to write more than a paragraph. They almost never are asked to edit and rewrite what they wrote. The wonder is not that many students write badly, but that they learn to write at all.

Second graders can learn keyboard skills, the operation of disk drives and printers and the command structure of reasonably powerful word processing programs in a few hours. Once they have done that, as Judy Anderson will tell you, they can go on to use computers equipped with word processors to write and edit, all through the grades. If they have access to electronic dictionaries, thesauruses and grammers, they can not only learn how to write well, but their spelling will quickly improve and their vocabulary will grow. Schools equipped with word processing software for their computers can stop teaching spelling and vocabulary with flash cards, and the rules of grammer from the text. Teachers can instead concentrate on coaching students in the are of writing, instead of on the mechanics, because the computer will be providing constant feedback and support with the mechanics. Students in such classrooms will be far better writers than those without access to computers equipped with word processing software, because they will be able to write and edit far more and with far less effort than they do now.

Or take data. Increasingly we live in a world in which the sophisticated use of data is critically important, whether it is used by the owner of the local tire shop to match his inventory with the customer's car or the factory foreman for statistical quality control. Whether or not you know what data is relevent to the problem you face, where to get it, how to format it, and how to analyze it will spell success or failure for the local construction contractor as well as the farmer.

With currently available data base management software, spread sheet software and simulations in their computers, future home builders could learn how to analyze stress in load bearing structures, future farmers could learn how to calculate the most efficient feed mixtures for individual cows, and everyone could develop a better intuitive feel for the way Newton's laws of motion work.

An increasing number of schools are using computers in the manner I have just described. The principal reason more are not doing so is that there are so few computers. Using computers in the way I have just decribed means using them in virtually every course in the curriculum, from the first grade through the twelfth. And it means using them a lot. Student's writing will improve dramatically if they use word processors, but not if they get access to word processors for only twenty minutes a week. If we want to use computers to improve students performance in writing, science, mathematics—in virtually every course in the curriculum—then we must have lots of computers, something on the order of one computer for every four students.

Secondly, we must be prepared to work very hard at changing the curriculum. Using word processing software as I have suggested implies a wholesale revision of the way writing is now taught and a very different role for the teacher in the classroom. Much the same can be said for using data base software in the social studies class or simulations in science.

Though we will have to develop some software, particuiarly good computer based models and simulations, the main challenge is to provide enough machines for schools to use effectively the software we have, and then to reshape the curriculum to match and to train teachers make the most of that curriculum. HR 3750 would move us substantially toward these goals and I am very hopeful that you will report a bill that is built on the foundation it provides. Thank you.

STATEMENT OF MARC TUCKER, DIRECTOR, PROJECT ON INFORMATION TECHNOLOGY AND EDUCATION, WASHINGTON, DC

Mr. TUCKER. Thank you, Mr. Chairman. I am Marc Tucker, Director of the Project on Information, Technology and Education. The project is funded by the Carnegie Corp. of New York, a private foundation. For the last 2 years I have been examining the use of computers in our Nation's schools and working with local, State, and Federal policy makers to help them make sure that computers are used to the greatest possible advantage for our students.

I very much appreciate the opportunity to present my views on the bills being considered by this committee.

What the Congress does this year about computers in our schools will, in my judgment, make a very big difference. The bills you are now considering represent very different—I don't believe complementary, I believe very different—conceptions of how computers should be used for education. Much of the language in H.R. 1134 and H.R. 4628 assumes that computers should be used as teaching machines and defines the problem in terms of creating high quality software and training teachers to use it. I believe, incidentally, that those are precisely the views that plagued earlier types of teaching machines and if we treat these machines as teaching machines, they will all wind up in the closet.

That view of what computers are represents, in my judgment, a profound misunderstanding of the potential of computers to improve education. Software, in my opinion, is not the problem. But if Congress proceeds as if it is, it would make it virtually certain that computers will contribute little, if anything, to the education of our students.

One bill, Mr. Wirth's bill, H.R. 3750, has, in my view, a good deal of promise because it recognizes the potential of the computer as a powerful tool in the hands of the students and, therefore, defines the problem mainly in terms of student access to computing capacity. Whether or not computers live up to their billing in the schools is more than anything else a function of how many computers the schools have and, even more important, how they choose to use them.

We are in the schools treating computers like books, as if they could not be used without learning their language, as if they were texts to be viewed or to be read. But computers are much more like pencils than they are like books and they are, incidentally, in my view, not at all like phonograph players, the analogy used earlier this morning. They are much more like pencils. They are tools just as pencils are tools, but far more powerful. They are extensions of the mind. What we are doing in the schools is like giving courses in pencil, or if you like, courses in record player—the history of pencil, the structure of pencil, the social implications of pencil, ethics of pencil. We know that pencils are tools so we make sure that are students have pencils. We do not give them pencils for only 20 minutes a week.

Computers are vastly more powerful and versatile tools than pencils and, as the future unfolds, people who are not versed in the use of computers are going to be very much more disadvantaged than those unversed in the use of pencils.

Before exploring the implications of using computers as tools in the classroom though, it might be useful to share some information about the current state of computing in our schools.

First the numbers. At the beginning of the current school year, there were about 325,000 computers and terminals being used in the schools for instructional purposes, which was up from just a little over 50,000 2 years earlier. More high schools have computers than junior highs and more junior highs than elementary schools. Only 14 percent of our school districts are without computers. Sixty-eight percent of our schools have at least one.

Last year, among high schools, twice as many of those serving the well-to-do had computers than those serving low-income children. Since then the gap has narrowed, but there is a long way to go to make up the difference.

All of that sounds terrific. The growth rate is just going right straight up through the ceiling. But growth rates can be misleading. Our schools are not stuffed with computers. On the average, our high schools have 11 computers each; junior highs, 7 elementary schools, 3½. 325,000 machines don't go far when there are 45 million school children. But even these numbers are misleading because not all of the available machines are in use. Shades of the past, by the way, some are already in closets and those that are in use are not in use throughout the school day. In fact, far from it.

A study by Henry Jay Becker of Johns Hopkins University tells the story. In the typical elementary school, the computers are only in use 11 hours a week. At the secondary school, only 15 hours a week. In one quarter of our elementary schools, in one-fifth of our secondary schools, the equipment is used on an hour a day.

Not all students who use computers get to use them every week. In our average computer-using elementary school those students who do get to use computers in any given week get to use them for less than 30 minutes. In our high schools, fewer students in the school usually get to use computers at all, but those students get a little more time on the machines.

Even more important—much more important—is the question of how these computers are used. 80 percent of student's time on computers is devoted to two uses—57 percent for computer literacy, which mostly means learning computer programming and; 23 percent for computer-assisted instruction, which mostly means drill and practice, much of it in arithmetic.

In my opinion, these applications are generally a waste of time. Only a handful of people make their living writing computer code in this country. While there is currently a shortage of professional programmers, most experts believe that by the time most of our current students leave school, we are going to need many fewer programmers than we now have. It makes no sense to train millions of students to program if we are doing it because we think that they will have to program computers in order to use them. The vast majority of people who use computers in the work force, including many who use them in very sophisticated ways, never write computer programs. But instead they use packaged programs written by others.

Though it is doubtless useful to know how to program in order to modify packaged programs when necessary, it is very much more important in the workplace to know how to use packaged programs.

Now the teaching of programming in the schools is a relatively recent phenomenon, but computers have been used to deliver instruction for many years. In the last few years, delivery has shifted mainly to microcomputers. For the most part, however, what the student sees on the screen is the old paper and pencil workbook with the computer turning the pages of the book, as one of the earlier witnesses noted. Those students who get their drill and practice on the computer do better than students in conventional classrooms. Another method, older teachers teaching younger students is both more effective and less expensive as a means of improving the basic skills of low-achieving students.

Computers are being used for this function, in my view, not because they do the job better than anything else. They don't. But rather because using them is trendy. It's a way to respond to the ways of the public that schools use computers.

Not all computer-assisted instruction is drill and practice in arithmetic and spelling and naming of State capitals. There are programs available to teach physics, chemistry, economics, more advanced topics in mathematics and a wide range of other topics. Educators complain about the quality of these programs and they have sought Government support to develop better ones. You saw the results this morning.

But in my opinion, there is no reason to believe that the current generation of computers will ever be very good at delivering instruction. They are not the next after instructional television. They are not another version of 16-millimeter film projectors. That's not it at all. Notwithstanding the testimony of Congressman Gore, I am here to tell you that there is no shortage of venture capital for software development. None.

I was just a few months ago in New York City talking to one of the biggest publishers in the land and was told that they alone were prepared to put up more than $100 million for software development just like that, but they don't see a market for it. There is nothing in that proposal that will produce a market for it. That's the problem. Two years ago the market for software was $27 million. This last year the total market for software was a little over $40 million. As one friend of mine said, "That ratio——

Chairman PERKINS. Let me ask you at this point, which bills do you prefer?

Mr. TUCKER. I prefer Mr. Wirth's bill and I am about to explain why—by a lot.

Computers are good trainers but poor educators. Using them to deliver serious instruction is to misunderstand what a computer is and how it can best be used. It turns out that if you think of the computer as a tool in the hands of the student rather than as a device for delivering instruction, then computers can be powerful aids to the learning process. We have most of the software we already need and that's why I prefer Mr. Wirth's bill.

Take writing. Most students from kindergarten through high school are rarely asked to write more than a paragraph. They almost never are asked to edit and rewrite what they wrote. The wonder is not that many students write badly, but that they learn to write at all. Second graders can learn keyboard skills, the operation of disk drives and printers and the command structure of reasonably powerful word processing programs in a few hours. Once they have done that, as Judy Anderson, will tell you in a moment, they can go on to use computers equipped with word processors to write and edit all the way through the grades.

If they have access to electronic dictionaries, thesauruses and grammars, they cannot only learn how to write well, but their spelling will quickly improve and their vocabulary would grow. If we had word processors on computers and we had lots of them in the schools, teachers could stop teaching writing with flashcards.

They could stop teaching spelling lists and vocabulary lists and giving grammar drill. What is really interesting to me is that when you do that in the elementary school program, you are not teaching writing. Most of our elementary school teachers don't teach writing. What teaching writing really amounts to, what it ought to amount to is teaching kids how to express complex thoughts in an articulate, compelling way and giving kids spelling lists and vocabulary lists and grammar drills doesn't do that. With word processing equipment in our classrooms, teachers could teach writting.

Or take data. Increasingly we live in a world in which the sophisticated use of data is critically important, whether it is used by the owner of the local tire shop to match his inventory with the customer's car or the factory foreman for statistical quality control. Whether or not you know what data is relevant to the problem you face, where to get it, how to format it and how to analyze it will spell success or failure for the local construction contractor as well as the farmer.

With currently available data-based management software, spread sheet software and simulations in their computers, future homebuilders could learn how to analyze stress in load-bearing structures; future farmers could learn how to calculate the most efficient feed mixtures for individual cows, which some are doing now in a little town in western Minnesota. And everyone could develop a better intuitive feel for the way Newton's Laws of Motion work.

An increasing number of schools are using computers in the manner that I have just described and the principal reason that more are not doing so is that there are so few computers. That's the bottomline. Using computers in the way I have just described means using them in virtually every course in the curriculum, not just in computer literacy, from the first grade through the 12th and it means using them a lot. Students' writing will improve dramatically, I believe, if they use word processors but not if they get access to word processors for only 20 minutes a week.

If we want to use computers to improve students' performance in writing, science and mathematics, in virtually every course in the curriculum, then we have to have lots of computers—something, I believe, ultimately on the order of one computer for every hour students. Second, we must be prepared to work very hard at changing the curriculum. Here, I think Mr. Miller is absolutely right. Just casting computers on the landscape, they will all windup in closets unless we pay attention to the curriculum.

If we, just for example, use word processing software, as I suggested, it implies a wholesale revision of the way teachers teach writing. The word processing software is available. If they continue to do the grammar drills and hand out the spelling words and do the grammar the way they currently are, there is no advantage at all in having word processing software on computers availability to kids. We need to totally re-evaluate the writing curriculum to take the best advantage of the equipment.

Much the same can be said for using data-based software in the social studies class or simulations in science and all of that is why I think that the teacher training provisions in Mr. Wirth's bill makes a lot of sense.

Though we will have to develop some software, particularly good computer-based models and simulations, the main challenge is to provide enough machines for schools to use effectively the software we already have and then to reshape the curriculum to match that and to retrain teachers to make the most of that curriculum.

H.R. 3750 would move us substantially toward these goals and I am very hopeful that you will report a bill that is built on the foundation it provides. Thank you very much.

Chairman **Perkins**. Thank you very much, Mr. Tucker.

Mr. **Miller**. Mr. Chairman, if I might. Unfortunately I am going to have to leave here at 10:30.

Chairman **Perkins**. Go right ahead.

Mr. **Miller**. One of the things that concerns me, if I understand what you are saying correctly, is that there is an insufficient number of computers in our schools and coupled with that, an insufficient understanding of how to best utilize computers, that those two things are tied together.

Mr. **Tucker**. Right.

Mr. **Miller**. I guess, historically, we would say;

> Well, districts are free to go out and buy whatever they want and they will make a decision, whether it's by informed members of the school board or uninformed, and a decision will be made and they will tell the parents, "We have done you a favor. We have purchased computers for the school."

One of my concerns is that we could end up with just a whole host of problems in this if we are interested in the nationalization, if you will, of access to computers by students and teachers. Why don't we just have a national competition for a computer that meets certain educational specifications and see what the best price is that we can get and get on with the purchase of the hardware and get on with the training instead of letting each and every jurisdiction determine. I don't know that much about computers, but as I read most of the literature, there is sort of a certain basic set of features that are necessary to drive most of the software that would be of concern here. But what we are going to do is we are going to throw this out into the so-called "free enterprise system" and, in fact, you won't allow for the broadest dissemination even within a school district, possibly even within a State, of educational materials. Isn't there sort of a GI issue that we could come up with?

Mr. **Tucker**. There is, of course. What you are suggesting is exactly what the British did. The BBC computer——

Mr. **Miller**. That's what I understood.

Mr. **Tucker**. The BBC computer is the Acorn computer and it is a nice machine. There is no doubt about it. But the degree to which you think that the compatibility issue is the problem—and some people think it's a critical problem—is mostly a function of what you think the computer is for.

Why is that? The reason is this. Eighty percent of what I think could be done with the computer in every class in the school, in every course, at every grade level, could probably be done with four software packages, what the people in the software industry call "productivity packages," which are already available. The funny thing about that is that they are available for almost all of the machines that the schools are now buying except for the ones that you can practically put in your pocket—the under $300 or under $200 ones.

Mr. **Miller**. My concern at this stage is not really——

Mr. **Tucker**. It is an absolutely vital concern if you think of the machine the way you think of a motion projector or a phonograph. That is, it's got the instruction on it and you load it onto the machine and it delivers instruction to students. But I think that is a dumb way to use computers. There is no evidence that they are effective teachers. I think it is impossible, physically, for the current machines to become effective deliverers of instruction, but they are phenomenal machines when you load with a small number of productivity packages and use them in the way that I just described and Judy Anderson and my friend right here—[indicating Robert Pope, Ms. Anderson's student]—will tell you about. Incredibly effective.

If you use them that way, with data-based programs, then the compatibility issue becomes much less important. But you are still on the right point. That is, the whole—what everything depends upon is what it is in the heads of the people in the schools. That is not only what the most appropriate use is, but having access to some information and experience of others about what kind of machine do I want to use——

Mr. **Miller**. One of my concerns is that we have a limited amount of money to spend, whether it's $300 million in Mr. Wirth's bill or $150 million a year in Senator Lautenberg's bill. Computers, to some extent, remind me of stereo equipment. People seem to have a great tendency to overbuy. They buy speakers that you could take the plaster off the walls with, but nobody would listen to it, but nevertheless you engage in that. As I look at the computer market, there's the same tendency, I would assume, to overbuy but all we need to do is meet the criteria that you have established for these elementary programs.

How do we make sure that the dollar goes as far as it possibly can and still provide the quality and the ability that you are talking about?

Mr. **Tucker**. One of the things, I think, in terms of the legislation that you have in front of you that is very important is how a computer is defined. There are definitions of computer and of computer software in the bills that you have in front of you and some of them alarm me a lot because they talk, for example, about being able to run three languages, which suggests to teachers and school administrators that the principle purpose of having a computer is to be able to program it, which I think is wrong.

Consider another image which you could have which is that the computers have to come with a standard set of productivity software. That is, an integrated word processor, data-based manager, spread sheet and so on. That would convey an entirely different image to school people of what computers are all about.

The BBC people, by the way, thought about these issues. One of the interesting things that they did was say that the Acorn had to have a communications port built into it, a port which would permit the machine to be used in a local area network with other machines.

So, I think without going the whole route—that is, without saying, "We want something to come forward and bid on the only machine which can now be sold to schools," which is, in effect, what the British did. You can attack some of these problems in the way you define the computer and appropriate software in the bills that you write. I think that aspect of those bills needs a good deal of attention in the context of precisely what you are talking about.

You can do virtually all of what needs to be done there and still provide a lot of interplay in the market, in my opinion, for the manufacturers and the entrepreneurs. I get very scared about standardizing things in the fields of computing and telecommunications because they are moving so fast. I think standardizing things at this point mostly puts you in the position of making sure that the schools are going to get out-of-date equipment. So I would avoid that and look more to the definitions in these bills, however you construct them.

Mr. **Miller**. Thank you.

Chairman **Perkins**. All right. Let's go ahead, Judy Anderson.

STATEMENT OF JUDY ANDERSON, TEACHER, EAST CONSOLIDATED SCHOOL DISTRICT, ST. PAUL, MN, ACCOMPANIED BY ROBERT POPE, STUDENT, EAST CONSOLIDATED ELEMENTARY

Ms. **Anderson**. Thank you, Mr. Chairman. I am Judy Anderson and, in addition to testimony, I would like permission to also enter into the record the attachment.

Chairman **Perkins**. Without objection, all prepared statements will be inserted in the record.

[Prepared statement of Judy Anderson and the attachment follow:]

Prepared Statement of Judy Anderson, Computer Specialist, East Consolidated Elementary School, St. Paul, MN

Thank you, Mr. Chairman. I am Judy Anderson. I am a computer specialist at East Consolidated Elementary School in St. Paul, Minnesota, where I have spent the last three years developing a model elementary computer lab. My work as a teacher is summarized in a four-page article by Joe Nathan in the April issue of "Learning Magazine", entitled "A Computer Specialist at Work." The Minnesota Educational Computing Consortium has been my mentor. I am the author, developer and programmer of EZ Logo, an introductory Logo program for young children, including a disk and documentation published and distributed by MECC. My work with MECC has resulted in two awards. I received an award MECC's State Teacher's Programming Contest for EZ Logo. A nomination by Don Rawitsch, Director of User Services at MECC, and Joe Nathan, author of Free to Teach, led to my receiving a Certificate of Merit in Electronic Learning's Educator of the Year Awards Program. I have taken advantage of several opportunities which followed from these awards. I am a contributing editor for a year-long, eight-part series of articles on staff development in "Electronic Learning Magazine." I have broad experiences locally as lecturer and instructor, serving many institutions: Hamline University, Macalester College, College of St. Thomas, University of Minnesota, and the Science Museum of Minnesota. Recently I have accepted other invitations to lecture and instruct around the nation. As a member of the faculty of the Learning Institute this summer, I will teach a three-semester-credit course entitled, "Making the Computer Your Teaching Ally," at five universities around the country. My comments today, however, reflect my personal views, rather than the views of any organization I have consulted.

You asked me, Mr. Chairman, to comment on three bills based on my experience. On reading them I find myself more in sympathy with Computer Literacy Act of 1983 H.R. 3750, than the others, partly because it fosters equal access to the development of computer skills for minorities and women, and is more likely to contribute to our nation's economic strength.

Inequitable disparity is evident in our schools today when one looks at which students are being given the opportunity to participate in computer-related activities and which teachers are being trained as computer specialists. Often high mathematical ability and achievement are the criteria used to select students and teachers for computer experiences. Current research clearly demonstrates the disparities between men and women in mathematics and how this disparity has produced a gap in the opportunities for men and women. That gap will broaden if mathematical ability continues as a key factor in selecting students and teachers for participating in the information revolution.

Disparities also exist for minorities. The facts from the May 26 Wall Street Journal are startling: 72.6% of the country's richest schools have instructional computers, while only 45.5% of the poorest schools have computers. One might argue that this distribution of sophisticated resources is justified by asserting that low-income, low-ability students are much less able to benefit from a computer environment. My experience has been to the contrary.

The East Consolidated students are convincing proof of how a computer environment promotes student competence in the use of new technologies, and consequently improves student's academic performance in all subject areas. East Consolidated is an inner city school with a model elementary computer lab in an older, low income area. With 700 students and 23 computers (a ratio of 30 to 1), each student visits the lab for 30–40 minutes every other day for the entire year. Classroom teachers remain in the lab with their students in order to relate the computer activities with classroom projects and learn more about computers from hands-on experience and assistance from the computer lab specialist (and the children).

While the most widespread use of computers today is computer-assisted instruction at the elementary level and programming at the secondary level, at East Consolidated we do very little of either. Computer literacy for our students is not another subject. Computer literacy for them is the ability to use the computer as a problem-solving learning tool to handle information more efficiently and effectively in doing their classroom activities. Tool software provides an environment for this type of computer usage.

In the computer lab at East Consolidated, we use about 500 disks. Five of those are commercially purchased tool software programs, and the others are storage disks for individual students' files. Tool software helps students access, organize manipulate, and communicate information. Students and teachers use tool software to do things with greater ease and efficiency. They accomplish tasks they already want to do—such as writing and handling information. Word processing is an example of tool software. It does not introduce a new activity, writing is simply accomplished through a different medium. Word processors are tools for writing and editing; students can easily make changes in their writings, and print out their work. Students come to see text as flexible and writing as a multi-staged process.

Word processing is an example of a tool which primarily facilitates the production end of the writing process. Other types of tool software can be used to facilitate other stages of writing. Database management systems, for example, can be used as prewriting tools to help students collect, organize, and discover patterns and relationships in information before beginning to write. Planner also helps students with the prewriting stage of writing by helping students decide what content to include in their writing through a process of electronic brainstorming, and finally printing out an outline to be used when writing. Graphing software and spreadsheets can be used to demonstrate and summarize relationships. Graphics languages, programs, and peripherals can be used to illustrate students' writings in preparation for the final stage of the writing process: publication.

A computer lab equipped with these types of tool software programs can provide a learning environment for students of all ages and abilities in any subject area. Tool software not only helps students do the current work of the classroom, but it also encourages new ways of working, learning, and teaching.

This detailed description of computer usage at East Consolidated has a purpose. It supports the recognition of four important priorities;

The need for educators to clarify the use of computers in our schools before purchasing hardware, training teachers, and developing software to avoid the ill-effects which have resulted from reversing that order.

The need to provide at least one computer for every thirty students.

The need to coordinate the purchase of hardware with the training of teachers.

The need for schools to purchase only a few quality tool software programs to provide a computer environment for students of all grades, abilities, and subject areas.

These four priorities relate directly to the titles of the Computer Literacy Act of 1983. Title III—Information Dissemination and Evaluation acknowledges the need for evaluation and information dissemination. I would hope that, initially, greater importance and energy would focus on the implementation of this title. The role of the computer in the classroom is still uncertain. Educators need to consider seriously their reasons for using the computer. This evaluation and dissemination lays the foundation for the other two purposes of this bill: providing hardware and teacher training.

Hardware acquisition and teacher training are both crucial and both related. During the last three years, I have spent a great deal of time teaching parents, teachers and administrators about the instructional use of the microcomputer. The key factors determining the effectiveness of my training efforts have been the availability and timing of teacher training and hardware purchases. Two situations are equally frustrating and ineffective: purchasing hardware without providing adequate teacher training, and training teachers without providing classroom computers.

School administrations and communities put pressure on teachers to use computers. Many times equipment is purchased and teachers are expected to use it with little or no training. The result: many computers are still unpacked. The other situation is also frustrating. Teachers spend valuable time and money taking computer courses, yet their schools do not have funds for hardware. In either situation teachers are helpless. Teachers are enthusiastic to learn about computers, but they face many problems: computer classes are costly, few are offered, popular classes fill quickly, and the content does not relate to their students' needs.

In my view, hardware and training must be inseparable. I heartily enforce both Title I—Acquisition of Hardware, the Title II—Teacher Training Institutes. Both are essential, and the implementation of these titles should be closely connected.

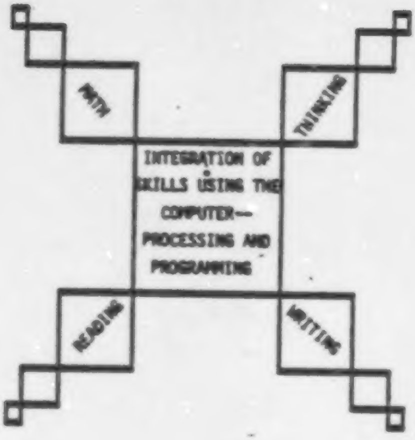
I agree with the bill's emphasis on the acquisition of hardware rather than on the development of software, which the emphasis in the two other bills under consideration. If the computer is used as a problem-solving tool for learning, hardware is the issue and not software. There are already many examples of tools on the market that work in educational settings and many others which are adaptable to class room uses. Computer-assisted instructional packages, however, must be created specifically for each subject, grade level, and use. While the high development cost of this type of software is important, the use consumer cost is even more significant. Tool software programs generally cost more than individual games or drill-and-practice programs, but the tools are much more cost-effective. They are adaptable to many or all subjects, so schools need far fewer of them.

In summary, I strongly support the Computer Literacy Act of 1983 for the following reasons:

It promotes equal access to computer equipment for minorities and women.

It focuses on the acquisition of hardware and providing teacher training, rather than software development.

Based on my experience at East Consolidated Elementary School, I firmly believe in both the goals and approach of this excellent legislation.


MATH
THINKING
INTEGRATION OF SKILLS USING THE COMPUTER--PROCESSING AND PROGRAMMING
READING
WRITING

BY

A Second Grade Class at East Consolidated School
St. Paul Public Schools

Judy Anderson, Computer Lab Teacher
Jane Hoyt, Classroom Teacher

Page
A4

#1 A House [illegible]
[illegible] -5

Mice
~~A~~ House Mouses and Rats
By Todd Mudek

A house mouse is not a very special mouse. It is called a house mouse because it lives in houses. ~~But~~ Other mice ~~that~~ are called field mice. Owls will eat mice. ~~And~~ There is also ~~are~~ the rat family. Rats are not as afraid as mice. ~~because~~ Rats will bite you, and cats will eat rats and mice. Mice and rats will eat almost any thing. They ~~thing that they need~~ eat cheese. Mice can eat through ~~these~~ anything. Here are some of the things: plastic~~k~~ and paper and other things. Mice can run very fast across the floor and on anything but slippery things. * Mice will get scared of you (space) if you jump becouse they are very scared of you. They are very defens~~ive~~ eless against ~~against~~ you. At night they will leave you a lone. ~~And~~ Mouse traps will kill rats and mice thaper ~~And~~ They can climb things ~~easy~~ like crates easily.

Todd. Put this sentance up by the star. *

anything is one word.

alone is one word

House Mice and Rats
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A house mouse is not a very special mouse. It is called a house mouse because it lives in houses. Other mice are called field mice. Owls will eat mice. There is also the rat family. Rats are not as afraid as mice. Rats will bite you, and cats will eat rats and mice. Mice and rats will eat almost anything. They eat cheese. Mice can eat through anything. Here are some of the things: plastic and paper and other things. They can climb things like crates easily. Mice can run very fast across the floor and on anything but slippery things. Mice will get scared of you if you jump because they are very scared of you. They are very defenseless against you. At night they will leave you alone. Mouse traps will kill rats and mice.

A5

House Mice and Rats
By Todd Mudek

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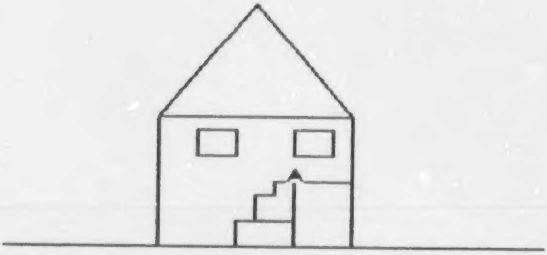
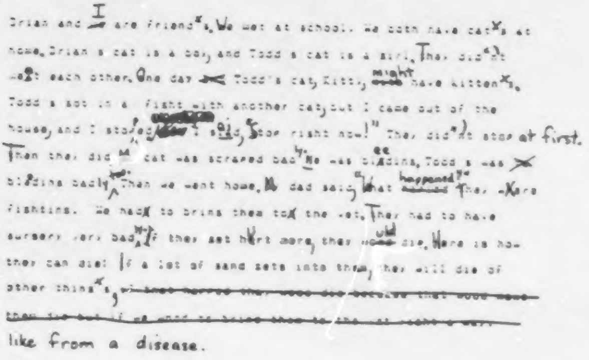


Brian & Hart Todd

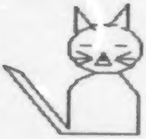
#1



Brian and ~~we~~ I are friends. We met at school. We both have cats at home. Brian's cat is a boy, and Todd's cat is a girl. They didn't meet each other. One day ~~[illegible]~~ Todd's cat, Kitty, ~~[illegible]~~ might have kittens. Todd's got in a fight with another cat, but I came out of the house, and I stoped. ~~[illegible]~~ I said, "Stop right now!" They didn't stop at first. Then they did. My cat was scraped badly. He was bleeding. Todd's was ~~[illegible]~~ bleeding badly too. Then we went home. My dad said, "What ~~[illegible]~~ happened?" They were fighting. We had to bring them to the vet. They had to have surgery very badly. If they get hurt more, they ~~[illegible]~~ would die. Here is how they can die: If a lot of sand gets into them, they will die of other things, ~~[illegible]~~ like from a disease.

Todd's Ca[illegible] Brian's Cat
By [illegible] chroepfer

Brian and I are friends. We met at school. We both have cats at home. Brian's cat is a boy, and Todd's cat is a girl. They didn't meet each other. One day Todd's cat, Kitty, might have kittens. Todd's got in a fight with another cat, but I came out of the house, and I stopped. I said, "Stop right now!" They didn't stop at first. Then they did. My cat was scraped badly. He was bleeding. Todd's was bleeding badly too. Then we went home. My dad said, "What happened?" They were fighting. We had to bring them to the vet. They had to have surgery very badly. If they get hurt more, they would die. Here is how they can die: if a lot of sand gets into them, they will die of other things, like from a disease.



Todd's Cat and Brian's Cat

By Brian Schroepfer

Brian and I are friends. We met at school. We both have cats at home. Brian's cat is a boy, and Todd's cat is a girl. They didn't meet each other. One day Todd's cat, Kitty, might have kittens. Todd's got in a fight with another cat, but I came out of the house, and I stopped. I said, "Stop right now!" They didn't stop at first. Then they did. My cat was scraped badly. He was bleeding. Todd's was bleeding badly too. Then we went home. My dad said, "What happened?" They were fighting. We had to bring them to the vet. They had to have surgery very badly. If they got hurt more, they would die. Here is how they can die: if a lot of sand gets into them, they will die of other things, like from a disease.

(Disc # 5) 5

Tara new story 5-3-83 Fennern
May 2, 1983

About Teeth Your teeth should be clean. I saw a movie about teeth. You shoud eat fruit like oranges and apples too. You should brush and Floss every day. See your dentist. You should eat popcorn and hard boiled ~~bolied~~ eggs and cheese. You should drink milk and water too. Here are some things that are bad for you: plaque and bacteria and sugar and acid and decay. So you think about what I wrote. Please brush your teeth every day to keep them clean! You have big teeth and little

Tara Fern[illegible]
May [illegible]

teeth. Same teeth have cavit~~y~~ies. They look gold. Some cavityes fall a.t. Some stay in, but ~~most~~ most stay in. That is all I have to say now about teeth! Good luck with yours!

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Title
NAME

#5

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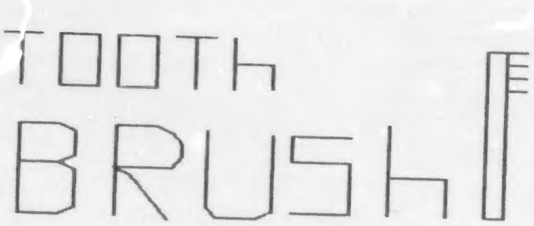
About Teeth

By Tara Fennern

Your teeth should be clean. I saw a movie about teeth. You should eat fruit like oranges and apples too. You should brush and floss every day. See your dentist. You should eat popcorn and hardboiled eggs and cheese. You should drink milk and water too. Here are some things that are bad for you: plaque and bacteria and sugar and acid and decay. So you think about what I wrote. Please brush your teeth every day to keep them clean! You have big teeth and little teeth. Some teeth have cavities. They look gold. Some cavities fall out. Some stay in, but most stay in. That is all I have to say now about teeth. Good luck with yours!



Chairman. **Perkins**. Go ahead.

Ms. **Anderson**. I am a computer lab specialist at East Consolidated Elementary School where I have spent the last 3 years developing an elementary model computer lab. The purpose of developing this lab, the purpose of this project has been to investigate ways in which elementary children can use the computer as a tool to support the entire curriculum and then the second purpose has been to teach to in-service teachers effective ways to do so.

Let me tell you a little bit about East Consolidated. It's an inner city school with 700 children and the computer lab has 23 computers which sort of meets the 30-to-1 ratio pointed out as necessary in the Wirth bill. Every child at East Consolidated, that is, all 700 children, visit the computer lab every other day for 30 to 40 minutes and the teacher also comes with to get hands-on experience right with the children and to learn not only with the children but from the children and from my expertise.

We feel that this model of in-service training has been very effective. At East Consolidated, we don't really see the computer literacy as another subject to be taught. We see the computer as a tool, a learning tool, a problem solving tool to help children do what they do in the classroom better and more efficiently and effectively. So we are really not concerned with using the computer for computer-assisted instruction or for programming. We are concerned with using the computer as a tool and using tool software to support the entire curriculum.

Word processing has been brought up quite a bit today as an example of tool software. Our children K through six at East Consolidated have been using the computer as a writing tool and have been successful at doing that. I think our use of the computer for writing with word processing has really made us as a staff stop and take a look at how we teach children writing, what is good writing. The answer that we have come up with and what we have learned from using word processing is that writing is a process. It involves many stages—prewriting, composition, revision, editing and finally, publishing. All of those stages are really important and integral and very important to teaching children good writing.

Another thing that we have learned from using word processing and in taking a look at the curriculum and really doing some new things is that writing really teaches children thinking and reading skills. When revision becomes the important part of writing, children have to stop and critically think and critically read and those skills are simultaneously being taught and retaught.

Next year we hope to use other tool software. We have sort of concentrated—put all of our efforts this year—into word processing and next year we hope to use a data-based management system for organizing and sorting and using that as a pre-writing activity to help children organize their thoughts before they write about them. We are going to take a look at some other programs for organizing the content.

So I guess my final statement about how we have been using computers at East Consolidated is we have been using them as tools and we have been using just a few pieces of tool software to do that. We have been teaching all children in all subject areas, at all ability levels, with those few pieces of tool software and we have been doing a very effective job.

Also with those few pieces of tool software, we have actually seriously taken a look at how children learn and how we can better—how we can improve the curriculum to do that.

After looking at the three bills and based on my experience at East Consolidated and working with a number of children and teachers, I am in strong favor of Congressman Wirth's bill, H.R. 3750, because it's focus is on hardware and not software. As I have just explained, using the computer as a tool model, to do that effectively you have to have the hardware. The software is there. I have 500 disks in my lab. Five of those are commercially purchased. The other 495 are student disks, disks with student files on them. I don't need a lot of software. The software that I needed and that I use was available 3 years ago when I had no computers. I knew what I wanted to do, but I didn't have the hardware. I didn't have the computers. I didn't have the tool. The software is there but what needs to be done is what we have just said. We need to inform teachers that it is there and how they can use it and how children can use it and we need the equipment to do it. So that is why I am in strong favor of Congressman Wirth's bill.

The other reason that we need hardware is for teacher training. I train hundreds, thousands, I think, of teachers in using the computer as a tool and it does no good at all if they come to my classes—and they do come and they do enjoy what they do—but they go back and they have no computers. I can meet with those same people 2 months later and they have totally lost all of the information and the skills that they have developed because they just do not have the equipment there to go back and use.

Well, that's enough about East Consolidated and about how I feel about the three bills. I have brought with me a student of mine, Robert Pope.

Chairman. **PERKINS.** Does Robert want to make a statement?

Ms. **ANDERSON.** He certainly does.

Chairman. **PERKINS.** Go ahead, Robert.

Ms. **ANDERSON.** Robert Pope, Mr. Chairman.

Mr. **POPE.** Thank you, Mr. Chairman. My name is Robert Pope. I am in sixth grade and I go to East Consolidated Elementary——

Chairman **PERKINS.** Just a little louder. We all want to hear you.

Mr. **POPE.** OK. My name is Robert Pope. I am in sixth grade. I go to East Consolidated Elementary School. Computers are part of our everyday life, as you well know. They are used in places like—they are used almost everywhere—businesses, factories, schools, homes, and lots of other places. I think the computers in the school are important because they teach us how to use the computers, which I think is important because most jobs in the future will probably be computer related.

At school, we use word processing, like Mrs. Anderson said, and that makes writing a lot easier. I think personally it has made me a better writer because it's a lot easier to revise and I enjoy writing more. For example, I wrote this testimony using one of the Apple IIe's at our school.

After we write our story and stuff, we usually illustrate them by using one of the three basic illustrators that we have which is

Logo, Easy Logo and a Koala Pad Microillustrator. Logo is a programming language that you can get for many computers and it uses commands like Forward 10, which drives 10 dots in a row to make a line. Easy Logo is a simplified version that the younger kids can easily use, in which they just do something like type "F" to go forward and "R" to go right and that kind of stuff.

If there weren't any computers in the school, there wouldn't be any word processing and so our writing skills wouldn't be used as much and we wouldn't be as well-prepared to get jobs.

Chairman **Perkins**. All right. Thank you very much. You made a good statement, Robert.

Our next witness is Dorothy K. Deringer. Go right ahead, Ms. Deringer. Identify yourself for the record. You are from Sunnyvale, CA.

[Prepared statement of Dorothy K. Deringer follows:]

Prepared Statement of Dr. Dorothy K. Deringer, Vice President, Atari Learning Systems, Atari Inc., Sunnyvale, CA

EXISTING PUBLIC POLICY (WHERE IT EXISTS) FOR PRE-COLLEGE STUDENTS: COUNTING COMPUTERS RATHER THAN MAKING COMPUTERS COUNT

The Grassroots Revolution

While there is significant revolution in the use of computers in learning, the revolution tends to be taking place outside of our educational institutions. Between five to seven million households now have a personal computer while about 325,000 are estimated to be in schools. A Gallup Survey found that while 51% of personal computer owners surveyed use the machines to play video games, 46% also said that they use them to teach their children spelling and mathematics.

Stimulating this out-of-school learning are computer programs that facilitate learning in a playful manner or what has been called "edutainment". Computer programs combining education and entertainment have been developed to make education both interesting and [illegible]

Computer camps are springing up all over the country. Clarkson College, for example, offers a family camp in which at least one parent must accompany the child for a week-long computer [illegible] and there are over 200 Computer Town USA! sites worldwide organizing and [illegible] whole communities in their effort to become computer literate.

Clearly, the pressure for computers in the schools is coming from parents, children and teachers in a grassroots fashion. These out-of-school developments are beginning to have catalytic effect on schooling.

Computers in the School

The widespread acquisition of computers is a new, rapidly accelerating trend: By the Fall of 1980, students had access to 52,000 compters for instructional use. In early 1982, that number shot up to 120,000 computers and since estimates indicate it has increased nearly threefold.

To date schools have relied upon such a variety of funding sources, such as Chapter I (formerly Title I Elementary and Secondary Education Act [ESEA]) and Chapter II of the Education Consolidation and Improvement Act programs of the Department of Education, local budgets, private donations and PTA and student bake sales. Special funding sources account for about half of their equipment acquisition to date.

Despite the funding limitations, most of the 29,000 U.S. public schools have at least one computer. About three-fifths of all secondary schools and one-fifth of all elementary schools have at least one computer for instruction. Even pre-school learning centers are involved: The National Association of Childcare Management reports that one quarter of the 20,000 licensed preschools are now using microcomputers. However, while acquisition is increasing, use is not very intensive. Computers are used for instruction on an average of about 2 hours per day.

Looking Ahead, Everything has Changed but Our Thinking

Clearly, the computer is being used a medium for delivering instruction, as an intellectual tool for problem solving and information processing and as an object of study in computer science and computer literacy. Many states are developing long-range strategies that will incorporate computers into schools. Four major strategies are in evidence. First of all, and ideally, each student would have a computer for use in computer-based curriculum or as an information resource much as one uses the library. Due to the expense and effort involved here, most systems are adopting a second strategy that would provide a computer literacy program for all students. Today in precollege education, computer literacy is the most frequently cited instructional application for computers. A third strategy recognizes the importance of computer science as a discipline: In this case all students would have a computer science program available to them. A fourth strategy limits computer use to teaching selected traditional subjects either through drill-and-practice or tutorials.

The presence of these computers has generated an enormous interest on the part of students of all ages. Irwin Hoffman of the George Washington High School in Denver, Colorado, points out that "Some of my students are waiting to get in the computer laboratory at 6 in the morning and are evicted by the janitor at 6 in the evening. And they beg us to open on Saturday and in the summer. If they want to meet with me to discuss problems, they meet me for breakfast at 5:40 am."

A variety of innovative teaching methods using computers are being experimented with. For example, the "Writing to Read" program created by John Henry Martin, a former school superintendent at Mount Vernon, N.Y., uses IBM personal computers with voice output and color graphics to help teach children to write before they read by having them translate phonetic sounds into writing. The Educational Testing Service is evaluating the pilot tests currently conducted by IBM Corporation using 10,000 five and six-year olds. The two years demonstration is planned to be completed this month.

Inequities in Computer Use

However, while the use of computers is increasing, striking inequities have already surfaced in school systems where computers have been placed. Ronald Anderson of the University of Minnesota reports that although opportunities for computer learning in our nation's schools are expanding, female, low income, and rural students are especially disadvantaged in obtaining access to computers in school. Other studies confirm his findings.

Gender: Twice as many boys have computers at home, according to Irene Miura and Robert Hess at Stanford University and boys are three times more likely than girls to enroll in a computer camp. In addition they found that a typical computer-owing family, fathers and sons regularly use the computer for programming, games and business purposes.

Income: The wealthiest schools are four times as likely to have micros as the poorest schools according to Market Data Retrieval, a Westport, Connecticut based research firm. Moreover, Dr. Anderson points out, students in rural and disadvantaged urban communities are less likely to use computers than students in other communities.

Race: While few differences exist between black and white students with regard to access to computers at school, minority schools tend to make extensive use of drill-and-practice software while white schools are likley to use computers for programming, according to a study by Henry Jack Becker of the Johns Hopkins University.

It can be said in general, access to and use of computers is greater for white males from middle class and more affluent locales. The inequities caused by affluence and social position outside of school appear to carry over into the schools. The traditional role of schools to minimize inequities and to open opportunities is not being fulfilled with regard to computers. and there are other problems as well.

Teacher Training

A serious factor inhibiting the intensive use of computers already placed in schools is the lack of teachers qualified to teach qualified to teach computer classes. Computer education requires trained teachers.

Many of the best teachers in the United States, particularly in mathematics and science, are leaving the teaching profession, and the most talented young people are choosing careers other than teaching where salary scales are low in comparision to industry. Moreover, most schools of education still do not require a course in computing as a requirement for graduation. The problem is compounded now that some colleges are forced to restrict enrollment in computer science classes to computer science majors due to shortages of teachers and equipment. As a result many school systems must provide their own in-service training programs. Approximately 30 states are now developing computer literacy guidelines for teachers and most are focusing on in-service rather than pre-service training. However, it will take many years to rectify the problem

High interest in computer science courses puts a special strain on schools without appropriately trained teachers. In 1983, the College Board survey of university bound seniors shows a significant growth in the interest in computer science: more than one in ten students now intended to major in computer science. Responding to this interest, many schools now offer an Advanced Placement (AP) Computer Science course that permits high school students to receive college credit. The course, which is designed to teach students how to write logically structured, well documented, computer programs using Pascal, has presented a hardship to many schools. Most teachers are not trained to teach Pascal. The reason is that 98 percent of these schools teach Basic while only five percent also use FORTRAN, LOGO and Pascal. This is likely to change in the near future.

Some educators now are starting to question the role of our traditional curriculum in an information age and they are re-evaluating the assumptions upon which the current curriculum is built.

A New Computer-Based School Culture

Seymour Papert at the Massachusetts Institute of Technology in Cambridge, proposes that computers can be used as "objects to think with": This will have the effect of restructuring the learning environment and creating a computer culture. Now, computers are used primarily as drill-and-practice instruments, because these are the only methods teachers are familiar with. To help remedy the situation, he and his colleagues have developed an educational computer language called LOGO. Using this language children still in elementary school have learned to write poetry, compose music, solve geometry problems and perform other conceptually exciting learning activities. Papert remarks the students lack encounters with ideas and materials that stimulate higher cognitive skills, but that computer-based learning can create a new educational culture in which there are no thresholds and no limits to learning. In short, he says we should not teach children mathematics but rather teach them to be mathematicians.

Mathemation: The Automation of Pre-College Mathematics

The computer automation of many of the traditional paper and pencil algorithms and the new trend toward heavy doses of problem solving in the precollege curriculum have led educators to reevaluate what and how we teach in precollege mathematics. The National Council of Teachers of Mathematics in its report "Agenda for Action" urges mathematics educators to take full advantge of the power of calculators and computers at all levels, and recommends a program geared toward making every student computer literate in the 1980's.

James T. Fey Associate Professor of Mathematics at the University of Maryland at College Park, and his collegues are reevaluating the precollege mathematics curriculum with an eye on the availability and widespread use of computers. The reshaping of mathematics education, he suggests, will require long analysis of curriculum and research on learning and instruction along with the development of experimental curricula and extension field tests. U.S. education, while it is full of contrasts between theory and practice, with respect to its objectives, will nevertheless rapidly assimilate the computer into the curriculum as a tool. Because powerful computers have entered business and industry in quantity, Fey suggests that students learn to use the computer for tasks they are now doing by hand (or not at all) in today's curriculm.

Some computer-based changes Fey predicts the curriculum will incorporate are:

Numerical Calculation. Numerical approximations for solutions to problem for linear systems, matrix inversions and differential equations are widely available for all computers and as pushbuttons on some calculators.

Symbolic Calculation. Sophisticated programs like MACSYMA and its micro counterpert MuMath perform symbolic algebra and calculus as proficiently as the most able high school and undergraduate students and, therefore, should be used as a tool.

Graphics. Graphs are valuable tools for thinking and communicating. New technology will make graphics the preferred tools for studying functions, dynamics and 3-D relationships.

Data Bases and Networking. A reference works become computerized students will turn to computer-based intelligent systems for aid in problem solving information retrieval. Thus, once a student has recognized the characteristics of a problem, a query to a national knowledge bank will summon appropriate help in problem formulation and analysis.

Technical developments are beginning to be incorporated into educational research laboratories. Intelligent computer-assisted instruction, for example, compares problem solutions with student progress and prompts the student to consider more productive strategies. New object oriented languages such as Smalltalk provide rich real or imaginary exploratory learning environments in which objects on the computer screen can be programmed to conform with physical laws. These developments are accompanied by the availability of computer-driven videodiscs which are used both as a complete, intelligent learning enviornments and as augmented memory and low-cost graphics.

What Role Will Industry Play?

The glowing promise of the new high technology industries, their need for technically trained workers and the willingness of schools and universities to buy computers even during a period of fiscal crises cause some to see industry as a source of support for implementing technology in education. Several computer companies have given substantial gifts of hardware and training to education nationwide and they have participated with the National Science Foundation in supporting research and development activities in science and engineering education. Individuals such as Steve Jobs of Apple Corporation have helped to draw national interest to computers in education with his hold offer to donate computers to schools. While these gifts are generous, they are few when compared to the National Need.

Many companies are entering the computers-in-education market; there are presently 250 publishes of educational courseware. If these companies are to survive, they must make a profit. Few have the vision and the dedication of William C. Norris, the Chairman of Control Data Corporation, to the concept of the computer as an important learning device. He has supported the Plato Computer-Based education project for over 15 years while reportedly investing almost a billion dollars in it and not yet turning a profit. The pressure for short-term profits results in an inability or unwillingness of industry to support the fundamental rethinking of what takes place in school education. The burden of restructuring of the educational system belongs to the educational community itself, along with the support of local state and Federal governments.

The Future

In a study of the impact informational technology has had on American education, the Office of Technology Assessment of the U.S. Congress cautions that if the public schools are to survive, educators will have to adopt a narrow, less ambitious set of goals if they are to gain public support. Educational futurists see demographic, economic and societal trends leading to greater conflicts and less consensus. The report concludes that it is clear that the use of computers and other forms of technology is far from being institutionalized at this time. A paucity of school funds, limited computer literacy among instructors and students, in addtional to the lack of high quality courseware serve to weaken the impact computers have. The report notes that it is difficult to predict when or if conditions will change. Harriet Taylor and James Poirot of North Texas State in Denton, Texas have a more limited but optimistic outlook in contrast with the OTA study. They conducted a survey of experts and their findings indicate that by 1990:

Computer literacy will be required by all high schools for graduation.

First year computer science courses now being taught in most colleges and universities will be taught in high school.

Computer science curriculum will be taught in high school.

The preferred languague instead of being nearly strictly Basic will be Pascal, Basic and LOGO.

What would it take to provide 40 million elementary and secondary school children access to an interactive computer for an average of thirty minutes a day by the year 1990? In a penetrating analysis Arthur Melmed of the Department of Education found that the costs of equipment, maihtenance and the development of 400 hours of high-quality courseware and materials would cost 1.29 percent of the per capita expenditure ($25 for equipment and $2.40 for courseware) by 1990, assuming as projected per capita expenditures for instructon will be $2500. This national "one percent solution" would provide 40 million elementary and secondary school children access to an interactive computer for an average of thirty minutes a day by 1990. While this is a relatively small amount of resources to tranform the curriculum for the information age, Melmed points out that the 1.29 percent that is needed is double what we currently spend on instructional materials (books, media, materials).

By contrast, other nations which have a centralized educational system, such as France, are systematically moving computers into their schools as part of a national economic and educational strategy to become information societies. Similarly, a national program in the United Kingdom has put at least one computer in every primary and secondary school with the assurance that every 16 year old leaving school will have had "hands-on" experience with a microcomputer. In 1974 Japan embarked on a 10-year plan to have all commercial and industrial high schools equipped with a computer by 1984: Now there are computers in 65 percent of their high schools. A new plan proposed by the Ministry of Education will place computers in all the nation's high schools, and a key part of the Fifth Generation computing effort is the effect that it will on education in Japan. The principal difference between these other countries and the United States is that they have a major commitment to integrate computing into the educational process as part of a national strategy; the United States does not.

If the experts and futurists are correct, this much is clear: The impact of the computer on learning depends not on computer access alone. Adding computers to the classroom without restructuring our educational system and its curriculum and without retraining a whole generation of teachers will more likely create computer anxiety than productive thinking and problem solving. The goal of computer literacy provides a new way for thinking about thinking. Certainly, the existing tendency toward counting computers rather than making computers count, must be changed if computers are to have an impact on education.

This document is heavily based on a paper that will be published in the IEEE Spectrum, V. 21, N. 6, June 1984. The entire issue, entitled Beyond 1984: Technology and the Indiviudal, will be devoted to the use of computers in education.

APPENDIX I

THE DECLINING HEALTH OF THE SYSTEM AND RECOMMENDED TREATMENT

Student scores on Scholastic Aptitude Test have been declining for the last 15 years, and U.S. schools report a general dissolution of the high-quality teacher cadre, and, in particular, a growing shortage of mathmatics and science teachers. Studies estimate that nationwide as high as one half of newly hired teachers were uncertified or were unqualified to teach these subjects; furthermore, approximately 30 percent of all science and mathematics teachers currently in secondary schools are either completely or severely unqualified to teach these subjects. Adding to this dilemma is a pronounced decline in the number of people preparing to teach. Of those high school seniors entering college this year, only 4.5 percent will enter education, half of what it was in 1973. For those that do become teachers of science and mathematics, the incentives to leave are numerous. Computer literacy and computer science programs tend to draw these teachers away from their normal teaching duties exacerbating problems in these areas. Once skilled in computing, teachers realize they can significantly increase their salaries by taking jobs in industry, thus creating shortages in computing, as well as mathematics and science. Last year almost five times more mathematics and science teachers left teaching positions for employment elsewhere than those that retired.

These conditions set into motion, as our society is want to do, a plethora of commissions and reports on what is wrong with education and studies on how to cure it. A significant feature of each of the reports is the role of computers in education. While the reports recognize the importance of computers, their recommendations about what to do vary widely.

The Department of Education's National Commission on Excellence in Education sees a rising tide of mediocrity and recommends immediate action to stem it. One change would elevate computer science to the level of a "basic" competency and recommends a semester-long computer science course s a requirement for high school graduation.

The National Commission on Precollege Education in Mathematics, Science and Technology, offers a blueprint for achievement in U.S. schools that will make them the best in the world by 1995. It too calls for a semester-long computer science course as a requirement for graduation. In order to meet this goal, the Commission recommends the establishment of teacher education and computer centers to demonstrate the use of technology, and calls on the Nation's schools to develop explicit plans to provide computer literacy.

The Carnegie Foundation for the Advancement of Teaching recommends a semester-long technology course that would explore the consequences of technology for society. It calls for teacher training in new technologies, federally funded resource centers and a National Commission on Computer Instruction to evaluate educational software. The Carnegie Report differs from others becasuse it assumes that computers for the non-specialist will be so convenient and user friendly in the future that little technical skill will be required. Therefore, the report's first priority is to have students learn about the social impact that technology has had and will have in the future.

"A Place Called School," by Dr. John Goodlad, is based on a multi-year study that calls for restructuring schools and reform of teaching. Dr. Goodlad asserts that computer skills are necessary for all students, and says we are beginning to recognize that the computer must be as much a part of tomorrow's shcools as the pencil is of today's. The Commission Reports have become required reading for educators and parents. Many national, state and local meetings are being held to discuss these recommendations.

APPENDIX II

DO COMPUTERS REALLY WORK IN EDUCATION?

While there is a lot to learn about the new technology, hundreds of studies have already sought answers to this question. In an analysis synthesizing the results of 51 independent experimental studies of secondary students, James Kulik of the University of Michigan found:

Computer-based teaching raised student scores on the final examinations from the 50th to the 63rd percentile.

Students developed more positive attitudes toward the computer and the courses they are taking.

Computer-based groups reduced substantially the amount of time needed for learning by approximately one-third.

Similar syntheses of research in elementary and higher education, business and the military, likewise reveal small but significant improvements in performance with large reductions (about 30 percent) in learning time to achieve objectives.

APPENDIX III

NEW TECHNOLOGICAL APPLICATIONS

Computers provide more than just drill-and-practice in education. The inventory of innovative programs grows daily.

Electronic Tinker Toys

Complex machines can be built electronically by children. Programs now available allow pre-school and elementary students to design and test a machine composed of logic circuits (Rocky's Boots ™), a machine in which the world's physical laws such as gravity can be varied, (Pinball Construction Set), and a factory to produce a variety of different parts to specification (The Factory). These programs stimulate logical and creative thinking, yet have the appeal of a game.

A Writer's Workbench

The teacher's advice, "Revise, revise, revise" is less tedious when the student uses a computer as a word processor. New tools such as a proofreader, thesauras and word choice editor offer advice on how to improve the readability of a piece of writing. Through the application of these tools the productivity of the writer is enhanced permitting greater concentration on style and clarity.

Simulations and tools to understand real-world phenomena

Simulations enable students to become familiar with complex processes that might otherwise be inaccessible, too expensive or downright dangerous. They come in all sizes and disciplines. Oregon Trail, for example, combines history with decision making for a trip west in the 1860's. Sixth graders survive on this westward trek by making judicious dcecisions about the use of medicine, food and supplies. Colors and coat patterns of generations of cats are investigated in Catlab, a laboratory for introductory genetics experiments which is used to supplement the classic drosophelia experiment. In addition, SCRAM, a nuclear power reactor game, and Odell Lake which explores behavior of fish in a body of water, enable students to explore the dynamics of the real world through computer-based models. Beyond simulations, new tools such as Atarilab ™ enable students to use the computer as a substitute for expensive laboratory equipment to investigate the behavior of phenomena such as temperature and light.

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SOFTWARE

Atarilab ™ by Dickinson College, Atari Learing Systems, Sunnyvale, CA.

Catlab by CONDUIT, The University of Iowa, Iowa City, IA.

The Factory by Sunburst Communication, Pleasantville, NY.

muMath by the Software Warehouse, Honolulu, Hawaii.

Odell Lake and Oregon Trail by the Minnesota Educational Computing Consortium, Minneapolis, MN.

Pinball Construction Set by Bill Budge, Electronic Arts, San Mateo, CA.

Rocky's Boots ™ by the Learning Company ™, Menlo Park, CA.

SCRAM by Atari, Inc., Sunnyvale, CA.

STATEMENT OF DOROTHY K. DERINGER, VICE PRESIDENT FOR ATARI LEARNING SYSTEMS, SUNNYVALE, CA

Ms. DERINGER. Thank you very much for inviting me to speak here today. My name is Dorothy Deringer. I am presently a vice president at Atari in which my responsibility is product development for high quality learning products for the home. I have had the privilege, however, of being a program officer at the National Science Foundation for a number of years. So I have spent a lot of those years thinking about the Federal role in some of these areas and now I have the opportunity to actually try to put something in the box and put on the retailer's shelf.

As the industry representative on your panel, I would like to first express thanks on behalf of the industry for your interest in this topic. For a number of years many of my colleagues in a variety of the computer industries have paid a lot of attention, thought, detail, and effort to try to use computers to help education, to help improve education and on their behalf as well as on ours, it's a privilege to be here.

I would like to speak about four things very briefly. I submitted a paper for the formal statement. The IEEE Spectrum has devoted their whole June issue to computers in education. That's a professional society of electronics and electrical engineers and this paper was accepted to be a statement on precollege education in computers. It gives an overview, but I would like to talk very briefly about four points.

First, who is using computers today for learning? Second, the issue of teacher training. Third, curricular issues, rethinking the curriculum, I think, is going to be appropriate and fourth, something that hasn't been mentioned on a national level today, but it's extremely important—that's policy concern.

First, who is using computers? We have talked a lot about the 325,000 computers estimated to be in schools. There is another number that is extremely important and that is that there are 5 million computers in the home today and that is a conservative estimate. In general, a variety of studies show that the students that have access to computers tend to be white, tend to be male, and they tend to come from middle class or more affluent families. One person has characterized this as, "The rich learn to program and the poor do drill and practice."

Now, regardless of what the Federal Government does or what this group does here today, a part of our society is going to learn a great deal about computing and I think that without some kind of Federal activity—industry has made many efforts to try to work with title I schools, to make donations to schools, to do a variety of philanthropic activities to help people who don't have computing—if we don't consider something on a national level, I think we are in danger of becoming a society of technocrats and technopeasants and I think that this is something that only the Federal Government has the power and the resources, has the power to ameliorate, and I think in the future that could become a very serious problem.

Second, teacher training. We have talked a lot about teacher training today. Teachers are the people on line in the classroom. They are the ones who have a responsibility every day to do something to improve the education of their students. Computer education requires trained teachers in an entirely different way, I think, than we were talking about teacher training in the past. You learn about computing not through a 2-day seminar. It's a long experience. You start out with 2 days. You come back time and time again to dedicated teachers such as you have heard testimony from today. But it takes years.

Now, this is something that I think is also a national area of industry. Industry can help. We can offer teacher training as one of the computer companies has done in a very altruistic fashion. They have offered computer education to every teacher in the country who would apply for it. But it's just a beginnning and we are willing and able to participate and help, but we are not able to carry the whole burden. I think that teacher training is really going to be the key to effectively using computers in the classroom. Unless you know how to do it, I don't care how wonderful the computer is—unless you know how to use it effectively, you are not going to get the full use and the full potential from it.

We have talked a lot about software today. A number of different people have a variety of opinions about what we need in software and courseware. I think we have heard what seem to be opposing opinions. Do we need more software or don't we? Do we need more courseware or don't we? I think one of the most wonderful things about the potential for computers in education is that different people have very different opinions and none, I believe, is right or wrong. I happen to have my own particular ideas about how computers are used most effectively, but other people have different strategies and I think in the kind of educational system that we have, which encourages diversity, I think people ought to be trusted to make a lot of their own choices. I think, in such a rapidly moving business, what you want to do is allow for new ideas, new strategies, new approaches to develop.

I believe that it's not just whether there is courseware or software. I think there is some fundamental rethinking that's going to be going on, that presently is going on, in how computers are going to affect what we teach. I would like to give you an example of a product, a Federal investment that I think we need in many, many different topics.

When I was at the National Science Foundation, we gave a grant to James Fay at the University of Maryland to take a look at how mathematics should change because computers are available. He took some students who hadn't done very well in algebra because of all of the manipulations that you have to do and he used a computer program called New Math to do the factoring for the students rather than having them do it by paper and pencil. He found with those University of Maryland students that many students who didn't do well before were actually doing well when they had the computer to do the grunt work and the kids could do the thinking. He and his colleagues have produced a booklet called, "Computing and Mathematics in the Pre-College Curriculum," which is a focal point for people all across the country to think about what we need to do with our heads now and what we can do with computers and I think books like this will change the curricula that we have in our schools presently. We are going to have whole different strategies of what we should be doing with our heads, what we should be doing with our time, and what we can now lend to the computer.

I think it's not just whether it's courseware or software that's the issue. It's what we are teaching in our schools that computers are stimulating discussion about. This is also something that is not even appropriate, I think, for industry to do. It's something which needs a more ecumenical approach and Federal investment is a way in which to effect that.

The last thing that I think is extremely important that we haven't talked a great deal about is policy. What do we think we should be doing on a national level with computers in education? What are our goals? What are our objectives? I am not talking about this in the sense of a national education system such as you might find in Britain or France or Japan in which they have made major national commitments to computers in education. I think we need a variety of different kinds of policy issues, policy strategies and policy goals that can be done for a relatively small proportion of the funds that you are talking about investing. I think that's an important addition that I would like to encourage you to think about.

If we don't know where we are going, most any road will get you there and I think we need some articulation of the issues and the long-term goals that we are pursuing in education in this country with regard to computing.

Thank you very much.

Chairman **Perkins**. Thank you very much. You made a very good witness.

Now if the Federal Government were to do anything in this area, should we emphasize teacher training or purchase of hardware or should we really do both? Which purpose is more important or are both equally important? I am talking about emphasizing the teacher training or the purchase of hardware or should we really do both? Give us an answer to that.

Ms. **Deringer**. My particular feeling is that teacher training is the most important part.

Chairman **Perkins**. You say teacher training?

Ms. **Deringer**. Teacher training is the most important part coupled with the evaluation of the curriculum. It's very difficult to be an informed user or purchaser of computers if you don't know what you are trying to do with them.

Now there is no question that there are many schools who do not have funds to purchase hardware and I think that that is important. That may sound a little unusual for you to hear from a representative of a computer company, but I have found that in the long term, people's goals and interests will be raised, they will be more effective purchasers and an informed customer and a knowledgeable customer is an excellent customer. I feel that's a rather commercial way to say, but from the other side, I think you have to know what you are trying to do and training and the challenges of training are the only way in which I think we can do that effectively.

Chairman **Perkins**. Did you want to comment on that, Mr. Tucker?

Mr. **Tucker**. Well, I am in substantial agreement. I want to reemphasize something that Dorothy said a moment ago, that if by training we mean a 2- or 3-day workshop at an elementary level in a programming language, we might just as well save our money.

Chairman **Perkins**. We might just as well forget about it, did you say?

Mr. **Tucker**. That's correct.

Chairman **Perkins**. If it's just 2 or 3 days.

Mr. **Tucker**. That's right. If what we mean by training——

Chairman **Perkins**. What duration do you think it will take to teach the instructors to use these computers?

Mr. **Tucker**. It depends entirely on what you are trying to do them. That is to say, if the object of the game, for example—to return to an earlier example—is to revise the writing curriculum in our elementary schools so that students learn to write not a little, but a lot, better and then to learn how to use computers as a part of a wholly changed writing curriculum, then I think you know might be talking about a summer at least and a lot of continuing work during the year and beyond that, over time. In other words, a sustained effort which is keyed to the needs, ultimately, of particular teachers in particular schools.

If the objective is to do something in science, it might be a little bit different, but it depends on what you are trying to do. The major point, it seems to me—and Dorothy made the point a moment ago—is that you are not teaching about computing. That is, you are not teaching somebody how to use a computer. The object of the game is to teach them how to use a computer in the context of a curriculum which they have thoroughly considered and reconsidered and probably changed in the process. That's more difficult and takes a longer time.

If you do that, then you get to the problem that was talked about even earlier by Judy which is, ultimately, that doesn't do any good unless they can get their hands on computers. So, in my view, the answer to your question, Mr. Chairman, is both. Doing one or the other doesn't make any sense. You have got to do both.

Chairman **Perkins**. Ms. Anderson, do you want to comment on that question?

Ms. **Anderson**. I would have to agree that the two, hardware and training, are inseparable. If you want to—you pointed out earlier that in forming some type of training to assist teachers in making a wiser purchase. In 1 or 2 hours, I can provide teachers with enough—just an overview of the use of computers and give them enough information to make a wiser purchase. But as far as using the computer as a tool for learning to really make an impact on children's learning, that type of training takes time and it takes the hardware. I have done it both ways. I have seen teachers—we have all seen teachers receive quite a bit of pressure from the community where the community will have a bake sale or a whatever sale and just dump the computers in the laps of the teachers. Those computers don't even get unpacked. So the hardware without the training—they are just going to sit in the packages.

The other way does not work. I know that. That is a fact that training without hardware is a waste of everybody's time. The other is a waste of everybody's dollars. The two, in my opinion, are inseparable. The timing of them is important. The two have to go together.

Thank you, Mr. Chairman.

Chairman **Perkins**. Let me compliment all of you people. You have been very helpful to us and we appreciate it. We hope to write a bill in the near future.

Ms. **Anderson**. Wonderful. Thank you.

Chairman **Perkins**. The subcommittee is adjourned.

[Whereupon, at 11:01 a.m., on Tuesday, May 1, 1984, the subcommittee was adjourned.]

[Additional information follows:]

OVERVIEW OF H.R. 3750

TITLE I: PROVIDES FUNDS TO LOCAL SCHOOL DISTRICTS FOR THE ACQUISITION OF COMPUTER HARDWARE

Sec. 101: Discusses purpose of the bill.

Sec. 102: Defines terms, including computer hardware.

Sec. 103: Outlines the allocation of the funds.

Sec. 104: Specifies the application process local educational agencies must complete in order to obtain funds over this title.

Sec. 105: Outlines the responsibilities of the State educational agency.

Sec. 106: Provides for the participation of chidren from private schools.

Sec. 107: Authorizes appropriates for this title.

TITLE II: ESTABLISHES INSTITUTES TO TRAIN TEACHERS IN THE OPERATION AND USE OF NEW TECHNOLOGIES

Sec. 201: Provides for a system of grants and contracts to be issued by the National Science Foundation for the purposes of establishing these institutes.

Sec. 202: Provides stipends for techers attending these institutes.

Sec. 203: Authorizaton of appropriates for this title.

TITLE III: PROVIDES FOR THE EVALUATION OF COMPUTER-RELATED TECHNOLOGY, DEVELOPMENT OF MODEL COMPUTER SOFTWARE, AND DISSEMINATION OF INFORMATION OF STATE AND LOCAL EDUCATIONAL AGENCIES

Sec 301: Provides for system of grants and contracts from the National Institute of Education and the National Science Foundation for the purposes.

Sec. 302: Provides for private evaluation and dissemination efforts.

H.R. 3750.—THE COMPUTER LITERACY ACT SECTION-BY-SECTION ANALYSIS

The bill's purpose is to provide assistance to local education agencies and institutions of higher education to promote computer literacy among elementary and secondary students and their teachers and for other purposes.

TITLE 1: ACQUISITION OF COMPUTER HARDWARE

Sec. 101: Defines the purposes of this section as authorizing assistance to local educational agencies for the acquisition of computers in order to promote student competence in the operation of new technologies and thereby improve their academic performamce.

Sec. 102: Provides definitions of the relevant terms in the bill. Defines computer hardware as including a data processor which can be programmed in at least three languages, has a random access memory capacity of a least sixteen thousand bytes, and is or can be connected with a screen for visual display. Furthermore, in connection with such a data processor there must be a display screen, and one more disk or tape drives. Finally, the definition inlcudes any equipment necessary for the installation of such equipment.

Sec. 103: Provides that 5% of the funds shall go to the State education agency for monitoring and enforcement purposes. The remaining funds shall be allocated to local educational agencies on a per capita basis. This section further specifies that local educational agency shall not longer be eligible for such assistance after reaching a ratio of one computer per thirty students.

Sec. 104: Establishes that in order to obtain funds under this title, the local educational agency shall have approved by the State Education Agency an application specifying the local agency's computer procurement program. The application shall contain assurances that the local agency will provide funds first to those schools with the least computer hardware per student and that the funds are not provided to any school that has reached a ratio of one computer per thirty students. The local agency must also provide assurances that parents will participate in the establishment of the computer hardware acquisition program.

Sec. 105: Each state which desires to have its local educational agency receive assistance under this act shall have on file with the Secretary an application submitted by the State education agency specifying the State's compliance with the requirements of this section. The requirements of this section include the adoption of standards to monitor the effectiveness of computer procurement programs and the adoption of written procedures for receiving complaints regarding such programs. Furthermore, each State education agency shall submit, as the Secretary requires, reports to enable the Secretary to carry out this title.

Sec. 106: The local education agency shall make provisions for the participation of private school children in these educational services. Expenditures for such purpose shall be equal, taking into account the number of children to be served and the needs of such children, to the expenditures for publc school students.

Sec. 107: There are authorized to be appropriated $300,000,000 for each of the fiscal years 1985 through 1994.

TITLE II: TEACHER TRAINING INSTITUTES

Sec. 201: The National Science Foundation shall arrange, through grants or contracts, for the development of short-term or regular session institutes for the purpose of instructing teachers in the operation and use of new technologies. The organizations eligible for such grants and contracts shall include nonprofit professional scientific or engineering organizations, science museums, regional science education centers, State Educational agencies, and institutions of higher education, including community colleges. The National Science Foundation, in making such grants and contracts, shall give special consideration to training those teachers who will be serving in elementary and secondary schools which have substantial numbers of culturally, economically, socially, and educationally handicapped youth or in programs for children of limited English proficiency.

Sec. 202: Those attending such institutes would be eligible to receive a stipend of $275 per week for the period of attendance at such institute.

Sec. 203: There are authorized to be appropriated $20,000,000 for each of the fiscal years 1985 through 1994.

TITLE III: INFORMATION DISSEMINATION AND EVALUATION

Sec. 301: In order to advise State and local education agencies on acquistion of computer hardware and software, the National institute of Education and the National Science Foundation shall, through grants or contracts, evaluate existing hardware software, disseminate the results of such evaluation and develop model software.

Sec. 302: The National Science Foundation, through grants or contract, shall conduct, assist and foster research and experimentation on, and dissemination of, models of instruction in the operation and use of computers. Organizations eligible for grants or contracts include nonprofit professional scientific or engineering organizations, science museums, regional science education centers, public television, State educational agencies, and institutions of higher education (includng community colleges). The Foundation shall give priority to those proposals which include the active and broad community involvement of such groups as parents, teachers, school boards and administrators, and local business, or to those proposals which call for establishing model training programs for adults. There are authorized such sums as may be necessary to carry out this function.

NATIONAL ASSOCIATION OF
ELEMENTARY SCHOOL PRINCIPALS,
Reston, VA, April 27, 1984.

Hon. CARL D. PERKINS,
Rayburn House Office Building,
Washington, DC.

DEAR MR. PERKINS: The National Association of Elementary School Principals has followed with great interest the introduction and discussion of the many bills that would assist schools by the provisions of computers and computer training for students and staff. The Elementary, Secondary and Vocational Education Subcommittee of the House Education and Labor Committee, which you chair, will shortly hear testimony on one of those bills, H.R. 3750, which you and Congressman Timothy Wirth (D-CO) have introduced.

The enclosed statement contains the views of NAESP on this measure. We would appreciate it very much if you would permit its inclusions as testimony for the record.

Thank you very much for your kind consideration of our request.

Sincerely yours,

EDWARD P. KELLER,
Deputy Executive Director.

Enclosure.

Statement On: H.R. 3750, The Computer Literacy Act of 1983.
Submitted To: The House Elementary, Secondary and Vocational Education Subcommittee—Carl Perkins, Chairman.
Submitted By: The National Association of Elementary School Principals Dr. Samuel G. Sava, Executive Director
Date: Tuesday, May 1, 1984.

The National Association of Elementary School Principals, representing over 22,000 elementary and middle school principals throughout the nation, is located at 1920 Association Drive, Reston, VA 22091. The Association's basic goal is to serve as an advocate for children, principals and the principalship. To implement this goal, if offers a varied and comprehensive program of services, benefits and activities.

The Association has long been interested in the numerous approaches being proposed for assuring the development of computer literacy in the classrooms of America. The themes of our 1983 and 1984 National Conventions centered around educational technology. Our annual National Fellows Program conducted in conjunction with the Florida Institute of Technology and Walt Disney World's Epcot Center focuses on educational technology and the leadership skills necessary for education in a computer age. Several of our publications have featured articles and "how-tos" regarding microcomputers. Many of our state associations have included workshops and seminars on microcomputers and computer literacy in their state association meetings and conferences. Elementary and middle school principals are concerned about computer literacy and are doing something about it.

We applaud the efforts of Congress to do something about it, too, and especially commend Chairman Perkins and Representative Wirth for their strong interest in this area. The introduction of H.R. 3750 exemplifies that strong interest.

NAESP is very pleased with the basic concept of the bill—to place computer hardware into all school buildings on a unit/children basis and to provide a strong training component for teachers and administrators. Doing so through appropriations rather than through tax legislation is also a significant point in its favor.

The Association does have several concerns with other sections of the measure that should receive additional attention. They are the state role, inclusion of private schools, training sites, and eligible agencies.

1. *State Role.* Section 105 (a) opens with "Each state which desires to have its local educational agencies qualify. . . ." To us that implies a state may not desire and, if not, eliminate all local agencies in that state from an opportunity to participate. I am sure that is not your intent. This language needs revision to assure that local educational agencies have that opportunity.

2. *Private Schools.* The inclusion of private schools in a district financial assistance program is substantially unconstitutional. The language itself speaks to services and participation in services. This title (Title I) is not a services title; it is an equipment acquisition title. It is therefore, illplaced and inappropriate. We object most strongly to this section and urge its elimination.

3. *Training Sites* It appears that "institutes" must be held somewhere other than at a site in the local educational agency using the specific equipment the local educational agency has purchased for its teachers, administrators, and students. Greater flexibility is needed so that on-site training may take place. There are many more benefits to this type of training than there are to off-site training.

4. *Training Eligibility.* Non-profit education organizations are not eligible for grants or contracts to conduct training institutes. They should be. Title II forces the bill into the Sub-committee on Science and Technology and uses that type of language almost exclusively. When serving training needs for education in operation and use of computers, education organizations have, and will continue to offer excellent training programs. Our collaboration with Walt Disney World's Epcot Center and Florida Institute of Technology is only one small example of what is being done. Such efforts should not be eliminated from consideration by restrictive wording in the bill to include scientific and engineering organizations only.

In summary, the National Association of Elementary School Principals appreciates greatly the efforts of Mr. Wirth and Mr. Perkins to bring this important issue to the attention of Congress. The above recommendations would strengthen H.R. 3750 and we urge their adoption.

Prepared Statement of the Association of American Publishers, Inc., Washington, DC

The Association of American Publishers (AAP) is the general association of book publishers in the United States. It comprises Professional and Scholarly Publishing; Higher Education; International; Direct Marketing/Book Club; School and General Trade divisions. Our some 300 member publishing houses produce the vast majority of the general trade, educational, reference, professional and religious books published in this country and found in the nation's libraries as well as considerable related audio-visual material and computer software.

INTRODUCTION

The subcommittee has three bills before it:

1. H.R. 1134, which amends ESEA Title III to establish National Centers for Personal Computers in Education. These centers, among other things, would provide information on computer courseware materials; develop such courseware materials; develop curricular materials for instructing students in the use of computers; provide teacher training and demonstrate computer systems; develop methods for enabling the handicapped to use computers; conduct programs demonstrating the various educational uses of computers; assess the relative quality and merits of commercialy available microcomputers; monitor new developments in educational technology; develop teacher training materials for computer education; establish a demonstration laboratory to exhibit examples of personal computer systems and courseware materials; publish a periodical newsletter on computers, computer training programs and courseware materials; assist the Congress and Federal agencies in advancing computer education and technology; assist lcoal libraries in establishing programs to provide personal computers and video disc systems to the public; and establish a model community personal computer center in a local shopping mall.
2. H.R. 3750, the Computer Literacy Act of 1983, which would provide funds to local educational agencies for the acquisition of computer hardware; establish institutes to train teachers in the operation and use of new technologies; and provide for the evaluation of computer-related technology, development of model computer software, and dissemination of information to state and local educational agencies.
3. H.R. 4628, the National Software Act of 1984, which would establish within the Federal Government a National Educational Software Corporation (NESC). The NESC would develop criteria for the selection of educationally useful computer software; secure investment capital for projects selected by the NESC to develop such software; make investments in projects for the development of such software; make contracts and grants to assist in software development; provide a clearinghouse to disseminate software information to schools; and engage in such other activitries as appropriate to encourage the development and use of such software.

Since provisions of the three bills overlap, if the committee acts favorably on these proposals it should combine the three measures, retaining those provisions with merit and rejecting those which have no merit. In addition, any legislation reported by the committee should be complementary to, and not duplicative of, the Emergency Mathematics and Science Education and Jobs Act (HR 1310), which passed the Hosue on March 2, 1983; the Advanced Technology Foundation Act, HR 4361, which was reported by the House Committee on Banking, Finance and Urban Affairs on April 24, 1984; and Chapter 2 of the Education Consolidation and Improvement Act of 1981.

Our testimony, therefore, is directed to individual provisions of the three measures befored the subcommittee rather than dealing with each bill separately.

UNDUE FEDERAL INFLUENCE

A long-time cornerstone of all Federal aid to education programs is what is now Sec. 432 of the General Education Provisions Act:

Prohibition Against Federal Control of Education

Sec. 432. *No provision of any applicable program shall be construed to authorize any department, agency, officer, or employee of the United States to exercise any direction, supervision, or control over the curriculum, program of instruction administration, or personnel of any educational institution, school, or school system, or over the selection of library resources, textbooks, or other printed or published instructional materials by any educational institution or school system*, or to require the assignment or transportation of students or teachers in order to overcome racial imbalance. [Emphasis added]

This provision had its origins almost three decades ago in the National Defense Education Act at which time it was known as the Morse-Taft Amendment, indicative of the agreement between liberal and conservatives that Federal aid to education should not mean Federal influence or control of local education practices.

Similar provisions are found in the Library Services and Construction Act (Sec. 2(b)), the Department of Education Organization Act (Sec. 103(b)), and the Job Training Partnership Act (Sec. 145).

Federal evaluation of software or other instructional materials would clearly violate this well-established hands-off mandate. What value judgments would the evaluators apply? And how would these value judgments change from administration to administration? What influence would such evaluations have on the adoption by local educational agencies of one item versus another? We strongly urge that no provisions for evaluation of software or other instructional materials be included in any bill reported by the committee.

INSTRUCTIONAL MATERIALS

Any legislation reported by the committee should recognize that the new technology requires not only discs, chips and other similar materials, such as textbooks, manuals and workbooks. One must contemplate not only the materials used in the computer itself but also the necessary complementary materials referred to.

The October, 1982 report the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, "Today's Problems; Tommorrow's Crisis", after recounting the teaching potential of the new technology, adds a cautionary note: "However,, computer software is generally inadequate, and the full potential of these technologies for instruction has received little attention.

The Office of Technology Assessment, in its report, "Information Technology and Its Impact on American Education", profers a similar conclusion: "OTA found that the most-often cited barrier to current educational use of technology was the lack of adequate educational software."

The cost of developing instructional materials to be used with the new technology is very high. Some companies have invested as much as $1.5 million in their computer software programs. Small companies are consequently often discouraged from entering the field. In addition, large firms are reluctant to risk substantial sums in enrollment areas which have a relatively small number of students.

A principal conclusion of the January 1981 Report of the U.S. Department of Eduction Task Force on Learning and Electronic Technology stated:

Many private sector companies have made tentative forays into developing technological products and services for education. The outlook for future efforts to expand the impact is not bright, largely because education systems provide few significant incentives to private-sector entrepreneurship in this area.

This finding impelled the following recommendation:

The Department should provide incentives to encourage private-sector/university combined efforts to develop exemplary "high quality" software for computers and videodiscs. This should be done in cooperation with school districts and stat education agencies that elect to participate in such ventures. The purpose is to get all involved in making the trade-offs that will be needed to successfully implement the new technologies in instructional settings.

We also cite the December, 1982 policy paper of the Council of Chief State School Officers, "Needs for a New 'National Defense Education Act' " which stated:

The fields of mathematics and science are particularly vulnerable to the rapid obsolescence of instructional materials. Allowable expenditures under any federal program should include assistance to school districts to maintain reasonably up-to-date texts and library resources. School districts and states could use funding to meet their needs, including at least:

New science and math sequences which match the stages of children's intellectural development;

Updated curricula which accommodate technological and social changes;

New mathematics and science equipment, including computer hardware and software.

In the light of the foregoing we urge that prime emphasis be given to the development of high-quality courseware, embodying both the latest knowledge and techniques, and involving, as the Department of Education Task Force report suggests, the combined efforts of the private sector and the academic community.

PRIVATE SECTOR PARTICIPATION

Congress recognized the importance of private sector participation in the development of instructional materials and curricula when in 1978 it added subsection (c) to Sec. 426 of the General Education Provisions Act (GEPA), the law which now applies to all Department of Education programs. The pertinent portion of that subsection reads as follows:

(c) In awarding contracts and grants for the development of curricula or instructional materials, the Commissioner and the Director of the National Institute of Education shall—

(1) Encourage applicants to assure that such curricula or instructional materials will be developed in a manner conducive to dissemination through continuing consultations with publishers, personnel of State and local educational agencies, teachers, administrators, community representatives, and other individuals experienced in such dissemination;

This private sector participation factor is not adequately recognized in the pending legislation. It is a matter of good sense that any measure adopted by the committee should reflect this mandate for private sector participation for it is based on hard experience. Too often have curricula and materials been developed with Federal assistance which now rest undisturbed in college libraries or academic files but are unused in the schoolroom. Textbook publishers have valuable knowledge of adoption procedures, schoolroom requirements, teacher problems and the myriad of other factors which go into the development and subsequent use of successful instructional materials and curricula.

In addition, just as the private sector has a recognized and proper role in the development of instructional materials and curricula, so it also has a role in the training of teachers in the use of such instructional materials and curricula. As a matter of long practice, publishers provide in-service training to teachers in the use of texts and workbooks which the school system has obtained from them. Such expertise should continue to be utilized.

BASIC RESEARCH

The Office of Technology Assessment report found that "to make the most effective use of technology, there was a need for R&D in learning strategies and cognitive development, methods for the production of effective and economical curricular software, and the long-term psychological and cognitive impacts of technology-based education. It is worthy to note that, based on the foregoing, OTA urges that "Congress should consider policies to:

"(1) Directly support R&D in these areas,

"(2) Encourage private sector investment from both foundations and industry, or

"(3) Encourage a combination of both by using Federal funding to leverage private investment."

Any legislation adopted by the committee should require the basic research urged by the OTC report.

Chief among the items to be mandated should be:

1. Research on the instructional uses of the new technology.
2. Research on what kinds of instructional materials should be developed to work with the new technology.
3. Basic research on how students learn through use of the new technology.
4. Research on how curricula can best be presented using the new technology and complementary instructional materials.

This research is in keeping with the intent of Congress as set forth in Section 405(a)(2) of the General Education Provisions Act which states that "The Congress further declares to be the policy of the United States to . . . help to solve or to alleviate the problems of, and promote the reform and renewal of American education * * *" and to "strengthen the scientific and technological foundations of education * * *."

COPYRIGHT

A principal detriment to the development of computer software has been copyright violation. The ease with which software can be duplicated and used in the classroom plus the ignorance of many educators of the copyright laws has made this a major problem.

If the committee should adopt legislative providing assistance to educational agencies in the acquisition of software, either through purchase or loan, such legislation should make certain that those receiving such assistance are sensitive to the nation's copyright laws and will follow them. Such a sensitivity, for example, should be reflected in any plans the bill might require educational agencies to submit.

In this connection, we invite the committee's attention to the policy statement adopted by the International Council for Computers in Education, a consortium of groups from six nations, including twenty-five U.S. State and national organizations; and 14,000 individual teachers of computer literacy and computer science:

Educators need to face the legal and ethical issues involved in copyright laws and publisher license agreements and must accept the responsibility for enforcing adherence to these laws and agreements. Budget constraints do not excuse illegal use of software.

Educators should be prepared to provide software developers or their agents with a district-level approved written policy statement including as a minimum:

1. A clear requirement that copyright laws and publisher license agreements be observed;
2. A statement making teachers who use school equipment responsible for taking all reasonable precautions to prevent copying or the use of unauthorized copies on school equipment;
3. An explanation of the steps taken to prevent unauthorized copying or the use of unathorized copies on school equipment.
4. A designation of who is authorized to sign software license agreements for the school (or district);
5. A designation at the school site level of who is responsible for enforcing the terms of the district policy and terms of licensing agreements;
6. A statement indicating teacher responsibility for educating students about the legal, ethical and practical problems caused by illegal use of software.

We urge that the provisions of the policy statement advanced by the Council be a part of the established policy of any educational agency or other entity utilizing Federal funds for software and potential recipients must attest to having such an established policy.

OTHER PROVISIONS

Federal education aid programs traditionally include a provision that Federal funds should supplement, not supplant, local and state expenditures. This has the effect that the Federal funds provide education aid, not mere financial aid. Such a provision should be included in any bill reported by the committee.

Similary, a maintenance of effort provision should be included. If a deficit-burdened Federal Government is expected to expend scarce financial resources to assist local and state education efforts, then the least that should be expected of such states and localities is that they maintain their own level of expenditures.

CONCLUSION

This testimony has been submitted with a sensitivity both to the need for budgetary restraint and the equally great need for a technologically literate and knowledgeable citizenery.

The report of the NSF study commission is aptly titled "Today's Problems: Tomorrow's Crises". What the Congress now does will bear either a title of "Today's Solutions; Tomorrow's Successes" or "Today's Neglect; Tomorrow's Failures". We opt for the former.

INTERNATIONAL BUSINESS MACHINES CORP.,
Washington, DC., April 30, 1984.

Hon. CARL PERKINS,
Chairman, Subcommittee on Elementary, Secondary and Vocational Education, House Education and Labor Committee, U.S. House of Representatives, Washington, DC.

DEAR MR. CHAIRMAN: Thank you for inviting me to testify in behalf of IBM on the use of computers in schools. Unfortunately, I had a previous commitment I was unable to change.

IBM has a profound interest in an increase in the computer literacy of the teachers of America's young people and through them the students themselves. And we have hope that computers are one tool that can improve instruction in basic courses. This interest stems not only from our industry's need for highly qualified new scientists and engineers as new employees or from the fact that increased computer literacy will create demand for our products. Most important to us is the fact that rising technical skills will be needed if every American citizen is to participate successfully and properly in our society and in our increasingly "high tech" economy.

IBM is concerned about the quality, training and sufficiency in numbers of science and engineering graduates in critical fields from our universities. If this country is to remain industrially competitive, we must have the innovative skills required to produce lower cost, higher quality goods and services and the teachers and professors to teach these skills. We support the efforts of the U.S. government through the mechanisms of the National Science Foundation and other science support agencies to foster university research programs and to use its R&D expenditures to meet national goals and to stimulate the enthusiasm of young graduates students to remain in the teaching profession. As a demonstration of its interest, IBM recently announced a grant program of $40 million to selected universities to upgrade the basic equipment needed to improve its manufacturing and engineering curricula, $25 million to graduage level business schools to increase emphasis on computer science, and a $6 million program to support young faculty in computer and natural science. But the emphasis on science and mathematics must begin earlier in secondary schools.

Today computers are used routinely in the administration of secondary schools to schedule classes, maintain inventories of books and supplies, schedule school bus routes, and provide grade and attendance record keeping. Computer literacy software is also rapidly advancing spurred in part by the heightened interest of parents in training for their children as a result of the growing presence of low-cost personal computers in the home.

However, software to support instruction in traditional subjects such as reading, mathematics, and science is still in a developmental stage. We are well aware of the desire of educators and parents to see computers used in the classroom to enhance the educational process as well as to increase computer literacy. And we share the concerns of many that a premature move by school districts to buy hardware without adequate training of teachers and planning for its use, can be a mistake. Because of this concern, we have arranged for several teachers to take sabbaticals and work in our Boca Raton facility. Here their job is to review proposed educational software and advise us as to its value in the real teaching environment. We believe strongly that much more research and development need to be done before the real promise of the use of computers to augment traditional teaching methods can be realized. At the same time, there is some good courseware available. IBM, as an example, announced 40 new educational software products in the past few months.

We do not believe lack of money to buy equipment is the major barrier to intelligent use of computers in the secondary schools today. But barriers do exist and must be broken down, First, teachers themselves must be taught. This was the challenge we accepted in initiating IBM's secondary school grant program. In 1983, we made grants of 1,500 personal computers to 88 secondary schools and 12 teacher training institutions to help develop teacher capability. In 1984, we extended this program to 26 additional states, the District of Columbia, and the Commonwealth of Puerto Rico.

Second, we must know more about how children learn. IBM has loaned 300 personal computers equipped with voice output and 600 typewriters to be used in a national test of the "Writing to Read" methodology developed by Dr. John Henry Martin. Sixteen thousand children from over 125 schools in fourteen states are participating, and the results will be independently evlauated at the completion of the two-year study this summer by the Educational Testing Service. In another approach, IBM has consulting contracts with professional secondary school teachers and teacher training institutions to help develop courseware.

Third, all participants in secondary education must be enlisted in efforts to develop computer-based instruction. We, along with many other courseware suppliers, are entering into arrangements with educational material publishers to speed the development and distribution of new courseware and to significantly reduce its price to schools.

I list these IBM programs to demonstrate our first hand knowledge that the interested parties: teachers, local and state school administrators, universities, equipment and software suppliers, and publishers—are highly motivated to move the computer into the classrooms as rapidly as the development of the technology will allow. The fact that adequate courseware is not as widely available as we all would like is not due to the lack of effort, but because it takes time and persistence to develop it. Above all, it must pass the test of usefulness to teachers in realistic, everyday school environments.

In your hearings you will be considering what should be the proper role of the federal government in promoting the use of computers in secondary schools. We believe there can indeed be a useful federal role. The best use of computers in the classroom still requires much development support activity. It is our experience, however, that the pursuit of answers by the parties close to the problem individually and collectively will more likely develop the multiplicity of approaches needed to make progress. Since, in our opinion, funding is not the major barrier to progress, any federal support should be sensitive to the absolute need for innovative initiative, avoiding, for example, premature federal standardization. Given our view of the nature of barriers to the wider use of computers in schools, it is very difficult for IBM to support major additional federal expenditures at a time when U.S. deficits are alarmingly out of control. Many states have surpluses, and NSF's science and engineering education budget has experienced rapid growth and is not yet fully committed.

Perhaps most important, secondary schools are traditionally local responsibilities, and we believe the increasing willingness of local communities, in conjunction with industry and universities, to improve secondary schools is a sound basis for progress. However, I do believe the report of the Commission on Pre-College Mathematics, Science and Technology Education for the National Science Board provides valuable guidance to the appropriate type and level of federal involvement.

We fully support these hearings as a forum for debate and discussion of this issue. We encourage you to invite representatives from the local organizations which are supporting the expanded use of computers in schools to testify.

Sincerely,

LEWIS M. BRANSCOMB.
Vice President.

See attached.

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EFFECTIVENESS OF TECHNOLOGY IN PRECOLLEGE MATHEMATICS AND SCIENCE TEACHING

JAMES A. KULIK

ROBERT L. BANGERT-DROWNS

Center for Research on Learning and Teaching
The University of Michigan

ABSTRACT

The first major applications of scientific technology to education were made by psychologist B. F. Skinner three decades ago. In the years since, the emphasis in instructional technology has shifted from programmed instruction to individualized systems of teaching to computer-based instruction. These three approaches show different degrees of promise as aids in precollege mathematics and science classrooms. Programmed instruction and individualized instruction have had only limited success in raising student achievement or improving student attitudes in precollege education. Computer-based instruction, on the other hand, has raised student achievement significantly in numerous studies, dramatically affected the amount of time needed for teaching and learning, and greatly altered student attitudes toward the computer.

Education has undergone several revolutionary transformations during its long history. The Carnegie Commission on Higher Education described three of the major ones [1]. The first occurred when societies began to differentiate adult roles and the task of educating the young was shifted, in part, from parents to teachers and from the home to the school. This specialization in function greatly increased both the efficiency and the uniformity of education. A second revolution occurred with the adoption of the written word as a tool of education. The use of written materials in teaching freed learners from the burden of rote memorization and multiplied the amount of information at their disposal. A third revolution came with the invention of printing and the subsequent wide availability of books. The printing press gave learners access to vast storehouses of ideas and information.

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Education is now being transformed by another revolution—a revolution based on the application of scientific technology to instruction. In the words of the Carnegie Commission on Higher Education [1], it is the "fourth revolution," and in the long run may change education as much as the three earlier revolutions did. Among the benefits that technology promises to bring learners are better, more comfortable, and faster learning—since students will be able to use technology to learn at their own pace and at their own convenience; opportunities to work with vastly richer materials and more sophisticated problems; unlimited, individual tutoring; and automatic measurement of learner progress.

The fourth revolution began modestly enough nearly three decades ago. The event that marks its beginning was the publication of B. F. Skinner's 1954 article "The Science of Learning and the Art of Teaching." [2] Skinner argued that automated teaching machines could make teaching more effective, and he described the programmed machines that he and his students had already developed. The design of the machines, he noted, was consistent with established laws of learning. The machines kept learners active, reinforced correct responses immediately and frequently, presented material in a controlled sequence, and gave learners control over their own learning rates. In the article's concluding paragraph, Skinner proclaimed the dawn of a new era in education:

> We are on the threshold of an exciting and revolutionary period, in which the scientific study of man will be put to work in man's best interest. Education must play its part. It must accept the fact that a sweeping revision of educational practices is possible and inevitable [2, p. 97].

Skinner's programmed machines and texts at first seemed destined to transform education, and instructional programs soon became available for every subject and grade level. Within a few years, however, critics began finding flaws in the programs. The fill-in-the-blank instructional frames, they charged, atomized lessons into tiny bits. The instructional sequences were too rigid and inflexible. The whole approach bored too many learners. The criticisms became more and more harsh, and by the middle of the 1960's, it seemed clear to many that Skinner and his colleagues were losing the first great struggle of the technological revolution they had started.

Hope for a technological era in teaching did not die, however. In the late 1960's prophets of a technological revolution hitched their hopes to a new star. Individualized instruction was the technology that was to change the shape of education. Like programmed instruction, individualized instruction emphasized individual work, self-pacing, and the achievement of mastery, but it used longer instructional units—often called learning activity packages or modules—and gave learners freedom to choose among different means of achieving precisely specified educational objectives. Individually Prescribed Instruction, Project

Plan, and Individually Guided Education became the best known of the individualized systems at the precollege level of instruction [3]. Such systems received a great deal of attention while the federal government was supporting their development and dissemination, but with the drying up of federal funds for educational research and development in recent years, interest in such systems has declined too.

Most recently, talk about a technological revolution in education has focused on the computer. To many, the computer seems the perfect vehicle to deliver instruction. It can require the student to respond actively; it can reinforce correct responses immediately; it can work at the student's rate; and it can follow a systematic plan of instruction. And the computer can also do other things that good teachers do. It can be an infinitely patient tutor, a scrupulous examiner, an engaging performer, and a tireless scheduler of instruction.

A British educator, writing about the development of instructional technology during the 1950's and 1960's, called his paper "Next year, Jerusalem!" [4] The title referred to a yearly declaration of hope made by millions of Jews that they would next celebrate Passover in Jerusalem. During centuries when there was little actual hope of realizing this goal, the faithful sustained their optimism with this declaration. Instructional technologists in the early years were in a similar predicament. Their hopes for the coming of a technological age were continually frustrated during the 1950's and 1960's, but they were able to keep up their spirits by concentrating on next year's successes rather than this year's disappointments and setbacks.

Today, instructional technologists no longer need to be stubborn optimists to believe in the coming of a technological age in education. Times have changed. The invention of the microcomputer has made these watershed years in the history of human society. Millions of people now use computers routinely at home and at work, and most will use them in their work by the end of the century. Every sector of society will be affected. Although only a few years ago our era was commonly thought of as the atomic age, the likelihood is growing that it will be remembered by future generations as the computer age. Education is not likely to escape the imprint that the computer is leaving on our times.

What impact will the coming technological age in education have upon learners? For more than two decades now, educational evaluators have been trying to assess the effects of instructional technology. This article draws together results from their evaluations. Like other reviews of findings on instructional technology, this one is selective. Its coverage is restricted to the major technologies developed during the last three decades: programmed instruction, individualized systems of teaching, and computer-based instruction. Another focus of this report is mathematics and science teaching at the precollege level areas where educational needs have been shown to be especially great. College level and non-science findings are included occasionally, however, to provide background for the major points.

PROGRAMMED INSTRUCTION

Typical of the reviews written in the first wave of excitement about programmed instruction are those by Silberman [5] and Schramm [6]. Silberman reported results from fifteen comparisons of programmed and conventional instruction. Nine of the comparisons reported superior learning from programmed instruction, and six reported no difference in the results of the two teaching methods. Schramm's report was based on thirty-six comparisons of programmed and conventional instruction. Eighteen of the comparisons reported no significant difference in achievement of programmed and conventionally taught classes, but seventeen studies showed a significant superiority for the students that worked with the programs, and only one study showed a final superiority for the classroom students. Eight of the experimenters reported a time advantage for the students using programs, and one experimenter mentioned a cost advantage.

Reviews from the fields of mathematics and science education reported results that were less favorable to programmed instruction. Briggs and Angell reported that only two of fourteen studies in science and mathematics classes found significantly higher examination scores for students taught with programs [7]; the other studies found no significant differences in results of the competing instructional methods. Zoll's review reported even less favorable results from the field of mathematics education [8]. Of the studies he reviewed in which programmed instruction was compared to a traditional method, three reported significant learning gains in mathematics in favor of programmed instruction, three reported significant learning gains in favor of the traditional course, and seven found no statistically significant difference.

Only a few limited conclusions can be drawn from these early reviews. First, programmed instruction often has no significant effect on student achievement. No significant differences due to achievement were found in 50 per cent of the studies reviewed by Schramm [6], in 40 per cent of the studies reviewed by Silberman [5], in 86 per cent of the studies reviewed by Briggs and Angell [7], and in 54 per cent of the studies reviewed by Zoll [8]. Second, when programmed instruction has a significant effect on learning, the effect is most likely to be positive. Of the studies reporting significant differences, Schramm [6] found that 94 per cent favored programmed instruction; Silberman [5] and Briggs and Angell [7] found that 100 per cent favored programming; and Zoll [8] found that 50 per cent favored programming. And third, programmed instruction often has a significant effect on the amount of time students need for learning.

Meta-Analytic Method

All of these early reviews used the same crude technique for integrating the evaluation results: the box score, or frequency count of studies favorable and unfavorable to a method. Although box scores may provide a general overview of an area, they have serious limitations. First, reviewers who construct box scores do not all use the same standards in classifying studies as favorable or unfavorable. Their dichotomous classifications often turn out to be unreliable. Second, box-score reviewers do not say *how much* better one method is than another; they simply report *how often* the method comes out on top. Readers need to know whether the victories are, in Glass's words, "by a nose or in a walkaway." [9] Finally, box-score reviewers do not use statistical methods to find the characteristics that distinguish studies with positive results from those with negative findings. Trying to distinguish between the two types of studies without using statistics is like trying to grasp the sense of hundreds of test scores without using statistical methods to organize the data.

To overcome the limitations of such box-score reviews, Glass introduced a set of objective review procedures which he dubbed "meta-analysis" in his presidential address to the American Educational Research Association [9, 10]. By meta-analysis, Glass simply meant the analysis of analyses, or more formally, the statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings. Researchers who carry out a meta-analysis first locate studies of an issue by clearly specified procedures. They then characterize the outcomes of all studies on a common scale of effect size. The effect size for a given study describes in standard deviation units the difference in performance of the experimental and control groups. Meta-analysts next describe study features in categorical or quasi-quantitative terms. Finally, meta-analysts use multivariate techniques to describe findings and relate characteristics of studies to study outcomes.

Achievement Effects

Hartley located a total of forty separate reports written between 1962 and 1974 on the effects of programmed instruction in elementary and secondary mathematics class [11]. These forty reports described results from a total of eighty-nine comparisons of programmed and conventional teaching of mathematics. In the typical comparison conventional and programmed classes differed in examination performance by only .11 standard deviations. The performance levels of the programmed and conventional groups were therefore virtually indistinguishable: at the fiftieth percentile for the conventional group and the fifty-fourth percentile for the programmed group.

C.-L. Kulik, Shwalb, and Kulik's meta-analysis covered forty-eight independent evaluations of programmed instruction in secondary schools [12]. More than two-thirds of the studies examined applications of programmed instruction in mathematics and the physical sciences. A few studies evaluated programmed teaching in the social sciences, and a few focused on programmed teaching in the humanities. A total of forty-seven of the forty-eight studies contained results from achievement examinations. The average effect of programmed instruction in these studies was to raise achievement test results by .08 standard deviations, or from the 50th percentile to the 53rd percentile.

Finally, J. Kulik, Cohen, and Ebeling located fifty-seven studies comparing effects of programmed and conventional instruction at the college level [13]. This meta-analysis covered many applications of programmed instruction to mathematics teaching and also covered applications of programmed teaching to the physical sciences, life sciences, and social sciences. Relatively few of the studies covered programmed teaching in the humanities. A total of fifty-six of the fifty-seven studies contained results from achievement examinations. In the typical college-level study, programmed instruction raised student examination scores by approximately .25 standard deviations, or from the 50th to the 60th percentile.

Achievement Effects and Study Features

Two factors seemed to affect study results (Figure 1). First, effects of programmed instruction appeared to be stronger at the college level than at the lower levels of instruction. As we have already indicated, the average effect of programmed instruction was to increase student achievement by approximately one-quarter standard deviation at the college level and by one-tenth standard deviation at the precollege level. A second factor that influenced size of effect was the time when the study was performed. Hartley reported a correlation of .39 between study year and size of study effect [11]; J. Kulik et al. reported a correlation of .31 [13]; and C.-L. Kulik et al. reported a correlation of .28 [12]. In each of the meta-analyses, later studies reported significantly larger effects than did earlier studies.

Relationships between size of effect and other study features were smaller and less consistent from meta-analysis to meta-analysis. Hartley, for example, found some evidence that evaluator involvement in the design of teaching and testing materials led to stronger effects [11]. C.-L. Kulik et al. also found some evidence that average effects were larger in the social sciences than in the physical sciences and mathematics, although this finding was based on a relatively small number of studies of programmed instruction in the social sciences [12].

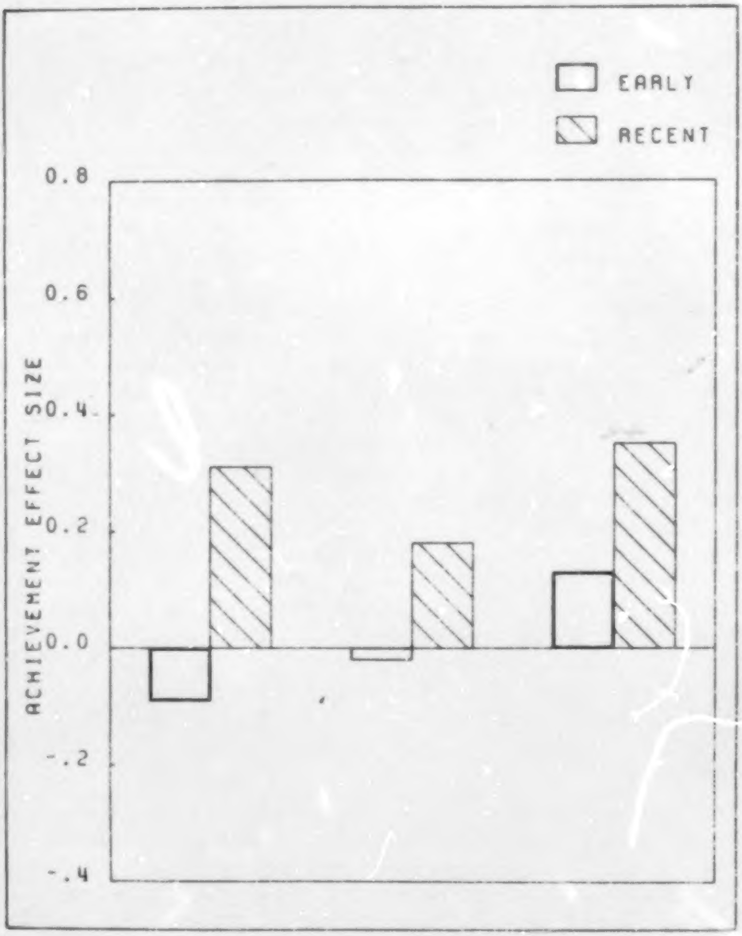

Figure 1. Effects of programmed instruction, as reported in early and recent studies.

Note: Study 1 is Hartley's meta-analysis of results from precollege studies [8]. Study 2 is J. Kulik, Cohen, and Ebeling's meta-analysis or findings from grades 6 through 12 [13]; Study 3 is C.-L. Kulik, Schwalb, and Kulik's meta-analysis of college level findings [12].

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Other Effects

Only a few studies located for these meta-analyses reported results on nonintellective outcomes of programmed instruction. C.-L. Kulik et al., for example, found results from attitudinal measures in nine of the forty-eight evaluations of programmed instruction at the secondary level [12]. In four of these nine studies, the programmed class rated the subject being taught more positively than did the conventional class; in the other five studies the conventional class gave the higher ratings. The average effect of programmed instruction on attitude measures was -.14. This implies that in the typical study, students in the programmed class gave slightly lower ratings to the subject being taught than did students in the conventional class.

Only four of the fifty-seven college-level studies located by J. Kulik et al. reported student ratings results [13]. Ratings of overall course quality were higher in the programmed class in two of the four studies, and conventional ratings were higher in the remaining two studies. On a 5-point scale going from 1 (lowest rating) to 5 (highest rating), the average rating of course quality was 3.41 in the typical programmed class, whereas the average rating was 3.49 in the typical conventional class.

J. Kulik et al. also reported that nine investigators collected weekly reports of study hours from students taught by programmed and conventional methods [13]. Six of the investigators found that programmed materials resulted in a time saving, and three reported a time saving with conventional teaching. On the average, the conventional approach required six hours per week of student time, and the programmed approach required about five hours. In general, we can conclude that programmed instruction makes no extra demand on student time and sometimes results in a significant time saving for students.

Conclusions

Given the expectations once held for programmed instruction, its record of effectiveness seems disappointing. Skinner and his followers expected programmed instruction to bring about a revolution in education. They expected it to make learning more efficient and joyful. The most thorough reviews of findings on programmed instruction showed that this method does not typically produce such results.

The most positive findings on programmed instruction came from college-level studies. Here, programmed instruction produced at least moderate positive effects on student learning, and programmed teaching also tended to reduce time spent in learning. Results from recent studies of programmed instruction were especially impressive. This improvement in study results may be due to improvements in the art or science of programming made over the years.

The outlook for programmed instruction in precollege mathematics and science teaching looks far less promising than does its future in postsecondary education. Learning effects were especially weak at the precollege level of teaching and in science and mathematics. Another negative point was the reaction of students to classes taught with programmed instruction. Programmed instruction does not produce enthusiastic acceptance of course content. This limits its application in the elementary and secondary schools. If our search, therefore, is for an instructional technology that will contribute to precollege science and mathematics education, we have to look beyond programmed texts and programmed workbooks to such contemporary offshoots of programmed teaching as individualized and computer-based instruction.

INDIVIDUALIZED SYSTEMS OF INSTRUCTION

Individualized systems of teaching usually require learners to demonstrate mastery of lower level skills before they move on to higher order skills. Mathematics is therefore considered by many to be an ideal subject for individualization since it is a hierarchically ordered field in which concepts generally build on the foundation provided by prior concepts. The early reviews of the effectiveness of individualization in precollege mathematics teaching, however, did not give a positive picture of the effects of individualization.

Schoen concluded that elementary school results were overwhelmingly against individualized instruction as measured by mathematics achievement [14]. At the secondary level, only one out of twelve studies reviewed by Schoen reported improved mathematics achievement in individualized classes, whereas three researchers reported greater achievement in traditional classes. Schoen also reported that no study at the secondary level showed improvement in the affective areas attributable to individualization. Schoen's conclusions were almost entirely negative:

> Over fifty studies in all grade levels aimed at showing the effectiveness of this approach demonstrate no consistent objective evidence that there will be student improvement of any sort. The most consistent result is less mathematics achievement with an individualizing approach [14, p. 356].

Hirsch's findings for mathematics instruction in grades 7 through 12 were similar [15]. Of the thirty-three studies that he reviewed in which individualized instruction was compared to group-based teaching, five reported significant learning gains in mathematics in favor of individualized instruction; four reported significant gains in favor of group-based instruction; and twenty-four found no statistically significant differences. Nineteen of the studies reviewed by Hirsch included results from scales measuring attitude towards mathematics.

Only three of the nineteen studies reported significant differences between the treatments. In each case, individualized instruction was found to be superior to conventional instruction.

Given the lack of positive findings at the precollege level, the college-level findings on individualized instruction seem almost startling. The individualized method studied most frequently at the college level is Keller's Personalized System of Instruction, or PSI [3]. A number of reviewers have reported that evaluation results for this method are highly positive [16–19]. A typical box-score review found, for example, that PSI improved student examination performance in 95 per cent of all studies, and it improved examination performance *significantly* in more than 80 per cent of all studies [18]. Box-score and narrative reviewers also pointed out that student ratings are highly favorable in PSI classes, but some reviewers cautioned that course withdrawal rates may be higher in PSI classes.

Achievement Effects

Hartley's meta-analysis on innovative approaches in mathematics instruction in the elementary and secondary school included fifty-one studies on individualized systems [11]. These fifty-one papers reported results from a total of 139 separate comparisons. Hartley found that the average effect reported in these studies was small. In the typical case, use of an individualized system of teaching raised examination performance by .16 standard deviations. This effect was only slightly larger than the average effect of programmed instruction in the studies examined by Hartley.

Bangert, Kulik, and Kulik located fifty-one separate studies on the effects of individualized systems of instruction at the secondary-school level [20]. A total of forty-nine studies reported results from achievement tests, and all but seven of these studies were in the areas of mathematics and science. The average effect of individualization in the forty-nine studies was to raise achievement test performance by .10 standard deviations, or from the 50th percentile to the 54th percentile.

J. Kulik, Kulik, and Cohen's meta-analysis of research on PSI in college classes presented a strikingly different picture of the effectiveness of individualized teaching [21]. The data for this meta-analysis came from seventy-five courses, taught both conventionally and by PSI, described in seventy-two different papers. A total of sixty-two of the seventy-five studies reported final examination averages in PSI and conventional classes. In the typical study, the average examination score in the PSI class was .5 standard deviations higher than was the average score in the conventional class. This means that in the typical college-level study PSI raised the final examination score of a typical student from the 50th to the 70th percentile.

Achievement Effects and Study Features

The results of the three meta-analyses suggest that individualized instruction has different effects at different instructional levels. The average effect of individualized systems was to raise examination scores by about one-eighth standard deviation at the precollege level and by about one-half standard deviation at the college level. The elementary and secondary effects are small; the college effect seems large enough to be important.

Meta-analysts working in a number of different areas have reported a significant relationship between study source and effect sizes. Studies located in dissertations often contain weaker findings; studies located in journal articles often contain stronger findings. Smith has reported on the consistency of this result in numerous meta-analyses carried out at the University of Colorado [22]. J. Kulik has discussed the consistency of this finding in University of Michigan meta-analyses [23]. In the typical meta-analysis, according to Kulik, the average effect reported in journal articles is .16 standard deviations higher than the average effect reported in dissertations.

The difference in dissertation and journal results is particularly striking in studies of individualized instruction (Figure 2). In Hartley's meta-analysis on individualized instruction in precollege mathematics education, the average of six effects described in journal articles was .59; the average of eighty-five dissertation effects was .12 [11]. In Bangert et al.'s meta-analysis on individualized secondary-school teaching, the average of ten effects described in journal articles was .29; the average of thirty-six dissertation effects was .06 [20]. In J. Kulik et al.'s meta-analysis on PSI in college teaching, the average of forty-six effects described in journal articles was .57; the average of three dissertation effects was .15 [21]. The pattern of college and precollege findings is thus more similar than it may at first appear to be. The difference between journal and dissertation findings are roughly the same at each instructional level. The overall meta-analytic results differ, however, because precollege findings were recovered mainly from dissertations, whereas college findings came almost entirely from journals.

Other findings on study features are less strong and less consistent from meta-analysis to meta-analysis. Hartley found that studies using new evaluator-designed teaching and testing materials showed stronger results than did studies using field-tested commercial materials [11]. Evaluator involvement in instruction thus seemed to strengthen evaluation results. J. Kulik et al. reported that PSI effects were stronger when different teachers were in charge of PSI and control classes and weaker when the same teacher taught both experimental and control sections of a course [21]. Kulik and his colleagues also found this relationship in other meta-analyses of college-level findings. A similar effect has not been established in meta-analyses of precollege findings.

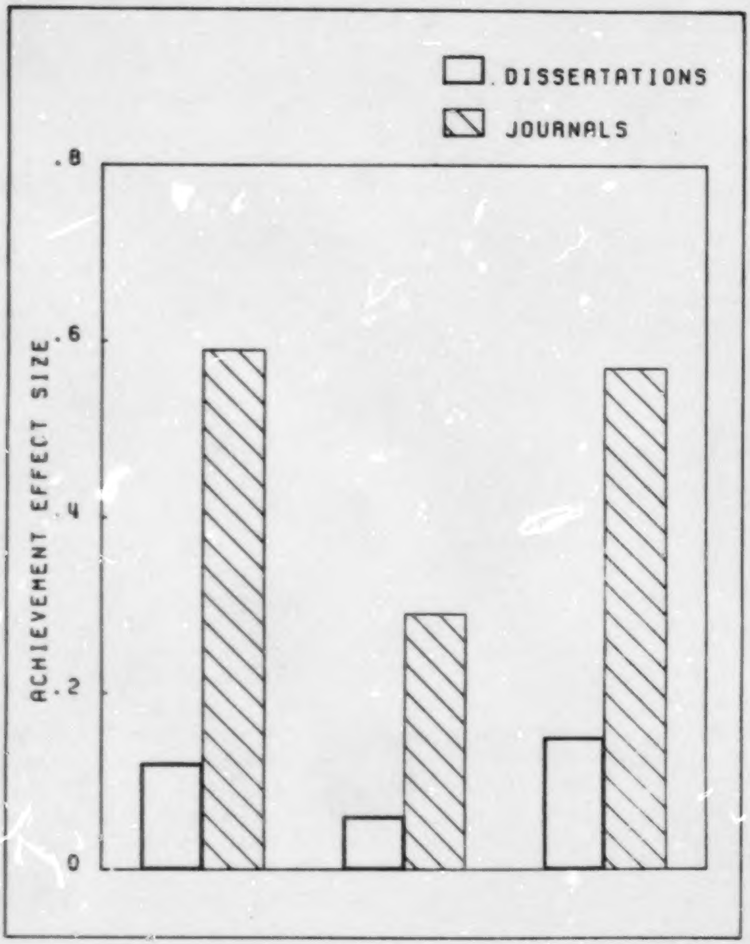

Figure 2. Effects of individualized instruction on achievement examinations, as reported in studies located in journals and dissertations.

Note: Study 1 is Hartley's meta-analysis of results from elementary and secondary schools [8]; Study 2 is Bangert, Kulik, and Kulik's meta-analysis of findings from grades 6 through 12 [20]; Study 3 is J. Kulik, Kulik, and Cohen's meta-analysis of college-level findings [21].

Other Effects

Bangert et al.'s meta-analysis also examined nonintellective outcomes of individualization in secondary school classes [20]. In general, these nonintellective effects were small. Fourteen studies, for example, contained results on student attitudes toward the subject matter being taught. The average effect of individualization in the fourteen studies was to raise attitude ratings by only .14 standard deviations.

As one might expect, results from individualized college teaching were strikingly different from these secondary school results. J. Kulik et al. reported that differences in student ratings of PSI and control classes were pronounced [21]. Students rated PSI classes as more enjoyable, more demanding, and higher in overall quality and contribution to student learning. Kulik and his associates also reported that PSI and conventional classes apparently make equal demands on student time. The difference in time spent in PSI and conventional sections of a course seldom amounted to as much as an hour or two for a complete semester.

Conclusions

Individualized systems of instruction have apparently made only limited contributions to precollege math and science teaching in the past. Such teaching systems have raised examination scores and improved student attitudes by only a small amount. The prospects for major contributions from this teaching technology in the future seem remote.

It is possible, however, that individual systems have not been expertly evaluated. The vast majority of evaluations at the precollege level have been carried out as dissertation research. Graduate students who produce such research are usually relatively inexperienced evaluators, working with limited resources under severe time constraints. Journal results–produced by more experienced evaluators with access to greater resources–may be more reliable than are dissertation results. If we were to give more weight to journal results than to dissertation findings in drawing conclusions, we would have to conclude that individualization shows some promise for improving instruction at the precollege level.

It is possible to argue, on the other hand, that dissertation and journal evaluations do not differ greatly in quality. Any differences in their results would then come from the different degrees of selection that are exercised in releasing the findings. Journal articles are reviewed at various levels for statistical significance; dissertation writers are more free to include nonsignificant results in their reports. Under this hypothesis, evaluations of individualized instruction at the precollege level have not appeared in journals as frequently as in dissertations because this form of instruction has not produced the kind of significant results that journals publish.

PSI's uniquely strong record of effectiveness also comes from an evaluation literature that has a unique characteristic. This literature is almost entirely lacking in dissertation evaluations. If dissertation writers had produced more evaluations of PSI, would their findings be as poor as those at the precollege level? There is no way to be certain, but one point is clear. There would have to be a large body of consistently negative findings to outweigh the impressive record that PSI has established in journal publications. To date, there is no evidence that a large body of unpublished negative results exists. It is probably safe to conclude therefore that individualization produces small improvements in precollege instruction and greater gains at the college level. Individualized systems of instruction may be most effective for mature learners working in the unconstrained environment of a college campus.

COMPUTER-BASED INSTRUCTION

The earliest reviews of CBI effectiveness concluded that the computer can be used to enhance student achievement, especially in elementary schools. Vinsonhaler and Bass's review, for example, reported on results from ten independent studies–three covering instruction in language arts and seven covering mathematics teaching [24]. The studies averaged 7.1 months in duration and provided a total of twenty-nine spearate comparisons of CBI and conventional teaching in mathematics. Results of most of the comparisons were statistically significant and favored CBI; only two of the twenty-nine differences favored conventional instruction. In the typical study, children who received CBI drill and practice plus conventional instruction showed performance gains of 4.5 months over children who received only conventional teaching.

Edwards, Norton, Taylor, Weiss, and Dusseldorp reviewed studies at various educational levels and in various subjects, and they also reached positive conclusions about the effectiveness of CBI [25]. Findings were especially clear when CBI was used to supplement conventional teaching. Of the nine relevant studies reviewed, all showed that normal instruction supplemented by CBI was more effective than was normal instruction alone. Findings were less clear when CBI was substituted, in whole or in part, for traditional instruction: nine studies showed that the CBI students achieved more than non-CBI students, whereas eight studies found little or no difference and three studies showed mixed results. Finally, all studies of instructional time showed that it took less time for students to learn through CBI than through other methods.

Achievement Effects

Hartley, who was the first to apply meta-analysis to findings on CBI, focused on mathematics education in elementary and secondary schools [11]. She reported that the average effect of CBI in thirty-five separate studies was to raise student achievement by .41 standard deviations, or from the 50th percentile to the 66th percentile. Hartley also reported that the effects produced by computer-based teaching were not quite so large as those produced by programs of peer and cross-age tutoring, but they were far larger than effects produced by programmed instruction or the use of individual learning packets.

Burns and Bozeman [26], like Hartley, used meta-analysis to integrate findings on computer-assisted mathematics instruction in elementary and secondary schools. In all, these reviewers located forty studies in which CBI drill and practice or tutorials supplemented traditional classroom instruction. They found overall effect sizes of .45 for computer-based tutorial instruction and .34 for drill and practice.

The meta-analysis by J. Kulik, Bangert, and Williams examined fifty-one studies of CBI in grades 6 through 12 [27]. A total of forty-eight of the fifty-one studies that they located reported achievement test results. More than 50 per cent of these studies examined CBI effects on mathematics teaching; nearly 25 per cent of the studies examined CBI effects in other science areas. The studies covered a variety of uses of the computer: drill and practice, tutorials, management of instruction, simulation exercises, and practice in programming as a means of increasing cognitive skills. The average effect of CBI in the forty-eight studies was to raise achievement scores by .32 standard deviations, or from the 50th to the 63rd percentile.

J. Kulik, Kulik, and Cohen's meta-analysis examined applications of CBI in college classes [28]. A total of fifty-four of the fifty-nine studies located for this meta-analysis looked at achievement test results. Nearly two-thirds of these studies came from courses in mathematics, science, and engineering; many of the remaining studies came from psychology and the social sciences. The effect of CBI in a typical class was to raise student achievement by approximately .25 standard deviations, or from the 50th to the 60th percentile.

Achievement Effects and Study Features

Meta-analysts reviewing CBI study outcomes have been unable to find consistent or strong relations between study features and results. Meta-analysis has been helpful, however, in raising questions about CBI effectiveness and in defining areas where more research is needed.

On the basis of findings on mathematics teaching, J. Kulik has suggested that CBI results may be a function of instructional level [23]. Computer-based teaching appears to raise examination scores in mathematics by approximately .4 standard deviations at the elementary level, by .3 standard deviations at the secondary level, and by only .1 standard deviation at the college level. Kulik suggested that at the lower levels of instruction, learners might benefit more from the stimulation and guidance provided by a highly reactive teaching medium. It is not yet clear, however, that this relationship between CBI results and instructional level holds true in all content areas. Until more evidence is available, Kulik's suggestion should be treated as tentative.

Short-term studies of CBI have sometimes reported stronger effects than have long-term studies. This suggests that the novelty of using a computer may play some role in its effects on students. Results on this factor, however, have not been especially strong or consistent from meta-analysis to meta-analysis. The difference in results from long and short studies reached borderline significance in J. Kulik et al.'s meta-analysis of secondary school results [27]; the superiority of short-term over long-term results was less pronounced and did not reach statistical significance in meta-analyses by Hartley [11] and J. Kulik et al. [28].

Meta-analysts have also suggested other relationships between CBI results and study features, but these relationships have not been firmly established. Hartley found that CBI was relatively ineffective in the few studies where it was used as a complete replacement for conventional teaching [11]. Other meta-analysts have not calculated effects separately for studies in which CBI substituted completely for conventional teaching, and so Hartley's finding still needs to be confirmed. J. Kulik et al.'s meta-analysis on secondary school applications of CBI found somewhat greater effectiveness in more recent implementations of CBI, reflecting perhaps an increase in the quality of CBI software [27]. Student achievement increased by .27 standard deviations in CBI studies carried out before 1970, but increased .46 standard deviations in studies carried out between 1976 and 1980. Other meta-analysts have not reported a time trend in study outcomes, but they also have not included so many recent reports in their analyses.

Other study features seem unrelated to CBI results. CBI results from both journal articles and dissertations are basically similar; studies from both sources show moderate achievement gains for students using computers in classrooms. Evaluator involvement in the computer-based teaching programs also appears to have little effect on achievement gains, when evaluator involvement is indexed by the affiliation of the researcher, the use of locally designed tests, or the use of materials untested in the field. Hartley provided evidence that such features make a difference in studies of programmed instruction and individualized instruction [11]; she was unable to find any evidence that such factors played an important role in achievement outcomes of CBI studies.

Other Effects

J. Kulik et al.'s meta-analysis of secondary school findings examined attitudinal effects of CBI [27]. These investigators found that the effects of CBI on attitudes toward instruction were small but the effects on attitudes towards computers were moderate to large. In ten studies examining attitudes towards subject matter, for example, the average size of effect was .12 standard deviations; and in another four studies examining ratings of the quality of instruction, the average size of effect was .19 standard deviations. In four studies investigating attitudes towards computers, however, the average size of effect was .61 standard deviations. Students who received part of their instruction on computer terminals, therefore, developed very favorable attitudes towards the computer.

J. Kulik et al. also located two studies on the amount of time students took to learn [27]. In one of the studies, students spent 135 minutes on instruction and study when taught with computers, and 220 minutes when taught in a conventional manner. The 39 per cent savings in time was equivalent to a size of effect of .78 standard deviations. In the other study, students spent 90 minutes on instruction and study when taught with computers and 745 minutes when taught conventionally. The 88 per cent savings in time is obviously great and of practical importance for teaching.

J. Kulik et al. also located college-level studies that examined CBI effects on attitudes and instructional time [28]. Results in these areas were consistent with J. Kulik et al.'s results at the secondary level [27]. The average effect of CBI at the college-level was to improve attitudes toward instruction by .24 standard deviations and to improve attitudes towards subject matter by .18 standard deviations. J. Kulik et al. also reported that in each of eight studies, the computer produced a substantial savings in instructional time [18]. On the average the conventional approach required 3.5 hours of instructional time per week, and the computer-based approach required about 2.25 hours. There appears to be little doubt, therefore, that students can be taught with computers in less time than with conventional methods of college teaching.

Conclusions

Evaluative studies showed that CBI has real potential as a tool in improving precollege mathematics and science teaching. The first criterion on which CBI excelled was student achievement. The average effect of CBI on precollege mathematics and science instruction was to raise student achievement by approximately .4 standard deviations, or from the 50th percentile to the 66th percentile. This compares favorably to the effects produced by other technologies. Both programmed instruction and individualized instruction raised student achievement in precollege mathematics and science by only .1 standard deviations.

CBI also showed good results when measured by the criterion of instructional time. Several studies showed that students can learn more quickly with computer assistance than with conventional teaching methods. Although the claim of quicker learning has been made for programmed instruction, findings for CBI are far more dramatic than are findings for programmed instruction. This time-saving effect of CBI is potentially as important as are its effects on student achievement.

A third important effect of CBI was to foster positive attitudes toward the computer. Students who learned with computer assistance felt more positively about computers than did students who received all their instruction by conventional means. Use of the computer in instruction may therefore help prepare students for the computer society in which they will live and work. With more than half of all workers projected to be using computers in their jobs by the end of this century, CBI effects on attitudes toward computers are of great potential importance.

One of the remarkable things about CBI studies at the precollege level is how robust the findings are. CBI findings were similar for different groups of studies carried out under different conditions. The worrisome complications found in studies of programmed and individualized instruction were absent from the CBI literature. Journal and dissertation studies of CBI reported similar results. Evaluator involvement in the development of teaching material did not seem to be necessary for positive results. CBI effects were acceptably strong in both early and recent studies.

One of the few things that may weaken seriously the effectiveness of CBI is its use as a *complete* replacement for conventional teaching. CBI is not often used in this way, but Hartley managed to locate a few studies in which CBI totally replaced conventional teaching [11]. She reported that the results of these studies were unimpressive. Total reliance on the computer as teacher therefore seems to be one thing that school systems should avoid. The effectiveness of CBI appears to be enhanced, on the other hand, by the use of up-to-date programs and computers. J. Kulik et al.'s meta-analysis covered a number of studies carried out in the period from 1976 to 1980, when programs and computers had increased in sophistication, and results from these studies seemed to be especially positive [27].

CBI results also appeared to be somewhat stronger at the lower level of instruction than at the higher levels. That is perhaps because programs developed so far exploit capacities of the machine most adapted to lower level learning: its patience in drilling and tutoring students and its capacity to respond immediately and appropriately to student answers. A major evaluation of CBI whose results were published too recently for inclusion in the meta-analytic studies shows what can be accomplished by an infinitely patient computer in an elementary school classroom [29]. The study was a four-year project conducted by the Educational Testing Service (ETS) in four elementary schools in the Los Angeles School District. In each of the schools half of the first through sixth graders were given access to 10 to 20 minutes of computer-assisted drill and practice in mathematics, reading, and language arts each day; the other half of the students did not receive this computer assistance. At the end of the first year, the CBI mathematics students were at the 64th percentile compared to the 50th percentile for the non-CBI students. At the end of the second year the CBI students were in the 71st percentile; at the end of the third year they were in the 76th percentile.

Although these findings are impressive, they are findings of the past, not necessarily of the future. This is an important point to keep in mind in the rapidly changing field of CBI. Evaluations seldom reflect the newest applications of the computer in teaching. Meta-analyses lag especially far behind the leading edge in development. They provide at best a summary of the major themes in reported evaluation findings. With developments in computer technology occurring so swiftly, no one can predict with confidence what the next year, much less the next decade, will bring in computer-based teaching.

SUMMARY

This evaluative review of the effects of instructional technology on learners made several major points:

1. Education is now undergoing a revolutionary transformation based on the application of scientific technology to instruction. This "fourth revolution" promises to bring changes to education as important as those produced by three earlier educational revolutions.
2. The use of educational technology has progressed through three stages: programmed instruction, individualized instruction, and computer-based instruction. These instructional technologies show different degrees of promise as aids in precollege mathematics and science classrooms.
3. Programmed instruction raised student achievement test results by only a small amount (.1 standard deviation), did not have positive attitudinal effects on students, and did not produce dramatic effects on student time to learn. Recent studies of programmed instruction and studies of its use in college teaching, however, presented a somewhat more positive picture of its results.
4. Individualized systems of instruction also raised student achievement in precollege mathematics and science classrooms by about .1 standard

deviations and had very small effects on student attitudes. Like programmed instruction, individualized instruction seems to be more effective at the college level, but the picture of effectiveness is clouded by the difference in results from journal articles and dissertations and by the different sources for college and precollege studies of individualized instruction.

5. CBI shows far more promise than the other technologies as an aid in improving precollege mathematics and science teaching. It raised student achievement by approximately .4 standard deviations in the typical study, dramatically affected the amount of time needed for teaching and learning, and significantly altered student attitudes towards computers. Recent studies have reported somewhat stronger effects than have older studies. The few available evaluations in which CBI was used as a complete replacement for conventional teaching rather than as a supplement, however, showed small effects.

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AVERAGE PERCENTILE ACHIEVEMENT LEVELS REACHED BY STUDENT TEST GROUPS BEGINNING AT THE 50TH PERCENTILE USING DIFFERENT INSTRUCTIONAL TECHNOLOGIES

Type of Instruction	Pre-College	College
Traditional	50th	50th
Programmed Instruction	54th[a]	60th[b]
Individualized Instruction	54th[c]	70th[d]
Computer-Aided Instruction	Elementary: 66th[a] High School: 63rd[e]	60th[f]

a. 40 studies reviewed in S.S. Hartley, Meta-Analysis of the Effects of Individually Paced Instruction in Mathematics (Doctoral dissertation, University of Colorado, 1977).

b. 57 studies reviewed in J.A. Kulik et al., Effectiveness of Programmed Instruction in Higher Education: A Meta-Analysis of Findings, Educational Evaluation and Policy Analysis, 2:6, pp. 51-64, 1980.

c. 51 studies reviewed in R.L. Bangert et. al., Individualized Systems of Instruction in Secondary Schools, Review of Educational Research, 53:2, pp. 143-158, 1983.

d. 62 studies reviewed in J.A. Kulik et. al., A Meta-Analysis of Outcome Studies of Keller's Personalized System of Instruction, American Psychologist, 34:4, pp. 307-318, 1979.

e. 51 studies reviewed in J.A. Kulik et. al., Effects of Computer-Based Teaching on Secondary School Students, Journal of Educational Psychology, 75:1, pp. 19-26, 1983.

f. 54 studies reviewed in J.A. Kulik et. al., Effectiveness of Computer-Based College Teaching: A Meta-Analysis of Findings, Review of Educational Research, 50:4, pp. 525-544, 1980.

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, DC., April 27, 1984.

DEAR COLLEAGUE: Last year the National Commission on Excellence in Education identified five new "basic" graduation skills for high school students.

Four of those basics—English, math, science and social studies—hardly qualify as "new." But the fifth skill, computer science, may have taken some of us by surprise.

Despite its new status as basic, computer skills are hard to come by in some school districts. Large, rich, urban or suburban schools, generally offer far more training in computers than small, poor or rural schools. And just as "Dick and Jane" texts were found to have gender and race biases in past years, educators now worry that computer software and access to computers may be tilted against females and minorities.

The International Council for Computers in Education (ICCE) is one group concerned about unequal access to computers. In a special theme issue of their regular magazine, this non-profit professional organization has prepared "Computer Equity," a copy of which is enclosed. In this magazine, twenty-one educators and public leaders discuss computer inequities and ways to combat these disturbing kinks in our school's computer systems. I hope you or your staff can take advantage of the information in this useful publication.

If you would like additional information about this booklet or other publications of the ICCE, please contact Anne Urban in my office at 225–0540.

Sincerely,

JIM WEAVER, *Member of Congress.*

Booklet retained in subcommittee files.

GENERAL SERVICES ADMINISTRATION,
Washington, DC, June 30, 1984.

Hon. CARL D. PERKINS,
Chairman, Committee on Education and Labor,
House of Representatives, Washington, DC.

DEAR MR. CHAIRMAN: The General Services Administration (GSA) wishes to submit its views on H.R. 4628, a bill "To establish a National Educational Software Corporation to promote the development and distribution of high-quality, interactive, and educationally useful computer software, and for other purposes."

GSA opposes H.R. 4628. The computer software industry consists of literally hundreds of vendors marketing thousands of products. It is not an industry for which venture capital is scarce. We believe that market forces should be sufficient to increase the quality and availability of education software without the intervention of a Government corporation.

The Office of Management and Budget has advised that, from the standpoint of the Administration's program, there is no objection to the submission of this report to your committee.

Sincerely,

RAY KLINE, *Acting Administrator.*

OPENING STATEMENT OF HON. CARL D. PERKINS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF KENTUCKY AND CHAIRMAN, EDUCATION AND LABOR

This morning the Subcommittee on Elementary, Secondary, and Vocational Education is conducting a hearing on the issue of computer education and computer literacy for our nation's elementary and secondary school children and teachers.

Three bills are currently pending before the Subcommittee dealing with different aspects of this general topic, H.R. 3750, introduced by our colleague Tim Wirth, would authorize $300 million for each of the fiscal years 1984 through 1993 for grants to local educational agencies to purchase computer equipment.

H.R. 1134, upon which the Subcommittee conducted a hearing on April 21, 1983, was sponsored by Congressman Downey. This bill would provide funds to establish and operate model centers for personal computers in education. These centers would develop and evaluate software, train teachers, and offer other types of technical assistance to educational agencies. The bill authorizes $4 million, which can be spread over three fiscal years.

Congressman Gore's bill, H.R. 4628, would establish a Government corporation to promote the development and distribution of high quality educational software. For this purpose, $15 million is authorized for each of the fiscal years 1985, 1986, and 1987.

We have a distinguished panel of witnesses today, including Senator Lautenberg, the House sponsors of these three bills, and several knowledgeable public witnesses.

PREPARED STATEMENT OF ROBERT POPE, STUDENT, EAST CONSOLIDATED ELEMENTARY SCHOOL, ST. PAUL, MN

Thank you, Mr. Chairman. My name is Robert Pope. I am in the sixth grade, and I go to East Consolidated Elementary School. I have 10 people in my family, two brothers, five sisters, and my parents. As you know, computers are becoming part of many peoples everyday lives. Computers are all around us. They are used in factories, homes, business offices, schools, and in many other places.

I think having computers in the school is very important because it teaches us how to use computers, which is very important since many jobs will probably be computer-related.

The computer also helps us alot because we can do many things more easily. The kids at East Consolidated work on word processing, which allows us to write, edit, and change our stories without having to rewrite after each correction. Word processing has helped me to become a better writer, and it makes me enjoy writing more. For example, I wrote this testimony by myself on an Apple IIe with a small amount of editing help from my teacher. Writing with a computer is easy, because it allows me to revise better. As a result, I write alot more than I would without the computer. Word processing also helps our reading skills because we read each others stories and point out possible changes.

We can illustrates our stories using any of the following: Logo, EZ LOGO, or the Koala Pad Micro-Illustrator. Logo, which is a programming language, allows students to draw pictures on the computer by giving it instruction like FORWARD 10 (draws 10 pixels in a line). EZ LOGO is a simplified version of Logo, in which a student just presses F to go forward, or R to go right. The Koala pad is like a small drawing board and you use a special "pen" to draw on it. It has special modes to draw certain things, and different brush sets to use in drawing designs. These functions and many others make it easier to use than Logo, and it enables you to make more intricate designs, although Logo makes a child think more.

If our school didn't have any computers, it would be very unfortunate. We wouldn't have the word processing capabilities we now have, and we wouldn't be as well prepared to get jobs in the future.

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